Metallurgical and Chemical Engineering

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Cleveland Meeting of the American Institute of Mining Engineers.

So much had been written and so much more had been said about the present situation in the American Institute of Mining Engineers that the outcome of the Cleveland meeting was awaited with the greatest interest by everyone. For this reason and because of the brilliant success achieved, it is a real pleasure to devote a large portion of this issue to the report of this meeting.

If any proof was necessary that the Institute in itself is as healthy and vigorous as in its youngest days, it was supplied in striking manner by the Cleveland meeting. Brilliant in its professional sessions and delightful in its social functions, it also was a symptom of the much talked-of "rejuvenation" of the Institute, as it was the first meeting held under the auspices of the newly founded Iron and Steel Division. There was a glorious array of papers on iron and steel metallurgy—all on hand in print or mimeographed and all eliciting interesting discussion. And yet the final touch was occasionally put on the discussion by the remark of an "outsider," as in the discussion of the function of alumina in iron blast-furnace slags, with which we deal in a separate editorial note on "the value of theory in metallurgical practice" on the following page. Such is the true function of a broad professional institution—to let every man specialize to his heart's desire and still keep him in close touch with his fellow workers in other fields.

It was a truly representative meeting and it augurs well for the future usefulness of the Institute. That in its present state of evolution, not everyone agrees with everyone as to details of policy, is only natural. It is natural that opinions should differ whether to change from a benevolent monarchy to a true democracy or to an oligarchy of "Fellows" although the answer which will be given by the whole membership can hardly be in doubt.

The idea of a special class of Fellows has in itself a few strong points. That engineers must take in future a decided stand on certain broad problems, is a point we have made only recently in connection with the deplorable cessation of power development at Niagara. But where to draw the line and whether it is necessary to create for this purpose a class of Fellows, are other questions.

All these questions will be worked out in time. The most urgent need in the present rejuvenation of the Institute is rejuvenation of membership. The attendance at Cleveland was perhaps too representative of the "stars" of the profession. It is suggestive to think of the amount of good that could have been done if twice as many of the young men had been there to derive inspiration from mingling with the leaders of the profession. Whether there shall be a selected class of Fellows or not, is relatively unimportant. The important problem is to "rope in" the young fellows—those who will be the leaders of the profession in years to come.

The Value of Theory in Metallurgical Practice.

The value of "high-brow" theory as an aid in solving practical problems in the iron and steel industry was very apparent at the recent meeting of the American Institute of Mining Engineers. We prophesy that two papers presented at this meeting will lead to further important research with the equilibrium diagram as a basis, and will go far to revive the hopes for it as a working instrument, which were disappointed because the investigations of Wuest, Goerens, Upton, and others were only partially satisfactory in their practical application, i.e. in explaining certain reactions in the manufacture of malleable cast iron.

Elsewhere in this issue we print practically in full one of these papers by J. E. Johnson, Jr., who is well known to our readers by his brilliant work on dry-blast operation of blast furnaces. Now, in setting himself the problem of improving the quality of charcoal iron, several months' investigation convinced Mr. Johnson that indispensable aids to this solution were: complete chemical analysis, metallographic examination, and finally the assignment of each grade of iron to its proper place in the iron-carbon equilibrium diagram. By these means he has already been able to determine some of the factors which produce good and bad charcoal iron, and thus to manufacture a larger proportion of the former. Incidentally, the investigation has enabled him to give us the first satisfactory explanation of so-called "spotted iron," that anomalous product with a gray exterior and white center, met with especially in Swedish charcoal irons, and which is one of the stumbling blocks of malleable cast-iron manufacture.

The second paper referred to above was by Professor Charles H. Fulton, whose experience has been chiefly with gold and copper metallurgy. He showed in a striking way that a discussion on slags, even by two men, experts in iron blast furnace operation, could not be satisfactorily concluded without a thorough knowledge of the general theoretical principles upon which the fluidity of slags depends, namely, the solution theory and the equilibrium diagram.

And thus we have a paradox, of knowledge which was practical because it was theoretical.

Assailing the Stamp Mill.

In his presidential address before the South African Institution of Engineers, Mr. J. A. Yule reviewed the metallurgical tendencies on the Rand and incidentally touched upon the use of the gravity stamp as a crushing machine. Mr. Yule is not the first to contend that the adaptation of the stamp to coarse crushing is taking that machine out of its legitimate sphere as a pulverizer of ore. This development in stamp crushing has resulted from the general acceptation of the tube mill as a secondary grinder for fine reduction, thus necessitating a greater coarse crushing duty on the part of the stamp.

Although prior to the introduction of the tube mill the stamp was considered an efficient and economical fine grinder, it is not generally conceded that it has retained this position when crushing ore to three or four mesh for subsequent tube milling. In view of the opinions of American Engineers on the subject, most of whom agree with Mr. Yule, it is interesting to note that his further suggestions also coincide with the theory and practice of Americans, who have advocated the use of jaw or gyratory crushers, rolls and ball mills as preferable means for coarse and medium crushing.

The water required in the large coarse-crushing South African stamps is greater than was demanded when the stamps were used as fine grinders. In some places this demand has become of material importance; and since there would probably be a reduction in water required by the substitute system mentioned, the latter offers an additional advantage outside the question of crushing efficiency. Water shortage suggests also the value of crushing in cyanide solution, where the recovery of gold and silver is effected mainly by the cyanide process. The Rand has been slow to adopt this practice which has become almost general in America, even where amalgamation and the concentration of sulphide mineral is an adjunct to cyaniding.

The points of capital expenditure and power cost also are touched upon by Mr. Yule, who is of the opinion that both would be reduced by the abandonment of the stamp as a coarse crusher, and the substitution of a two or three-stage system using rolls or ball mills following jaw or gyratory crushers.

While the foregoing is the opinion of the president of a society of engineers, we note also that a South African mining paper has recently ventured the prophecy that the last large Rand mill has been built in which heavy gravity stamps will be used in their present capacity as coarse crushing machines.

A Need in the Metallurgy of Low-Grade Base-Metal Ores.

The problem of how best to treat low-grade base-metal ores is always with us, and offers a fruitful field for speculation and experiment. And yet, with all the processes which have been devised and reached the patent-office stage, it cannot be said that much has been accomplished in a commercially practicable way. The great demand remains unsupplied, viz., some process which will be to low-grade complex base-metal ores what the cyanide process is to low-grade gold and silver ores.

Consider, for example, the comparative simplicity and success of the cyanide process, and its adaptability to small isolated mills and low-grade ores, yielding marketable bullion at the mine. Compare then with this the present series of treatments given to an ore containing small percentages of, say, copper, lead, and zinc, or any two of these metals, no one of which may exist in profitable quantity. Substantially all the metals must be recovered if the ore is to be treated at a profit. But so far as being able to recover these metals at the mine, only the first operation of concentration is performed by the mining company, which then relinquishes its interest in the subsequent operations of smelting and refining which are conducted by foreign companies. The gold-mining operator may build his own reduction plant and produce marketable metal. The base metal miner may only beneficiate his ore, with an attendant loss which may be greater than that sustained in any of the subsequent processes, for which also he has to pay.

The demand, therefore, is for a process which will yield base metals directly to the producer of the ore. Some such processes have been suggested and are under development; others have

not yet been given an opportunity to demonstrate their worth. It is realized that, in stating this demand, a most difficult problem has been stated. But we must realize also that experiments in low-grade base-metal industry ought to follow this line, and that metallurgists and ore-treating companies may well consider researches in this direction, instead of following routine testing along lines already well-known and adapted.

The Output of Steel Products.

The American Iron and Steel Association has made public the statistics of the production of rolled iron and rolled steel in the United States in 1911. These statistics are really of more import than the statistics of steel ingots which were published seven months ago, for they refer to steel in its commercial form. The statistics of steel ingot production, generally referred to as the "steel production" have their uses. They furnish a convenient measure either of the growth in capacity of the industry, or the degree of employment of capacity, and they also furnish, what is of perhaps equal importance, a means of measuring the activity of the different steel making processes as classified by the statistical gathering body, acid Bessemer, basic and acid open-hearth, crucible, and electric. *En passant*, it may be remarked that it would be of decided interest if a segregation were made of steel made by the duplex process, now designated merely as basic open-hearth steel. Perhaps the statistical department of the American Iron and Steel Institute, which is to gather the statistics in future since Mr. James M. Swank is retiring after forty years of signally valuable service in this capacity, may be open to suggestions leading to further improvement in American statistics, though it must be confessed that its maiden efforts have not gained for it much prestige.

The statistics of steel ingot production, while useful in certain respects, are not the statistics of the production of commercial steel, for steel is not sold as ingots. The statistics of rolled steel, just published for 1911, refer to steel in its commercial form, substantially the steel after it leaves the last pass in the hot rolls and has been sheared. Thus these statistics include rolled forging billets, because they are not to be rolled further, but billets for the rod mill are not included, since the rods instead are reported. Nail plate, on the other hand, is included. In the following table there is shown the production of rolled iron and of rolled steel in the past eight years, in gross tons. From 1891 to 1903 inclusive rolled steel and rolled iron were not separated in the statistics.

ROLLED MATERIAL, GROSS TONS.

	Iron.	Steel.	Total.
1904	1,760,084	10,253,297	12,013,381
1905	2,059,990	14,780,025	16,840,015
1906	2,186,557	17,401,911	19,588,468
1907	2,200,086	17,664,736	19,864,822
1908	1,238,449	10,589,744	11,828,193
1909	1,709,431	17,935,259	19,644,690
1910	1,740,156	19,881,123	21,621,279
1911	1,460,615	17,578,556	19,039,171

The figures for rolled iron deserve a word of comment. For many years the wrought iron industry was regarded as decadent but the experience of recent years compels an abandon-

ment of that view. As a rule, wrought iron products command higher prices in the market than steel products of similar form and the fact that they are thus purchased cannot be set aside. The last year before the hiatus in the separation of iron from steel in the statistics was 1890, in which year the production of rolled material was as follows, in gross tons:

Iron	2,518,194
Steel	3,504,681
Total	6,022,875

The production of rolled iron had been gaining, but there is reason to believe, in the absence of statistics, that it decreased after 1890. In recent years the production of rolled iron has averaged not far from 2,000,000 tons, and if the 2,518,194 tons produced in 1890 represented the maximum, the wrought iron industry should be regarded rather more as a stationary industry than a strictly decadent one. It may be argued that the industry of 20 or 25 years ago was one of puddling virgin pig iron, whereas the industry now is largely one of working up old material, and in support of this argument the fact can be adduced that in 1911 the total of forge pig reported produced was only 408,941 tons, and a portion of this iron was undoubtedly used in foundry operations, particularly in the production of cast-iron pipe, leaving but little forge pig to contribute to the 1,460,615 tons of rolled iron reported for the year. To this argument it can be rejoined that there is a considerable tonnage of wrought iron produced by manufacturers who definitely follow the practice of puddling pig iron, or a close substitute in the form of cast iron scrap, while the supply of old scrap suitable for busheling and cognate operations is likely to increase rather than decrease, thereby promising a continuance of such operations. With the more general use of the open-hearth steel making processes designed to reduce the need for scrap, the duplex, Talbot, and such processes, it does not appear as certain as it did a few years ago that the basic open-hearth is destined to absorb all the supply of old material not particularly fitted for the foundry cupola.

The rolled steel production of 1911 was 17,578,556 gross tons, which is quite a different quantity from the 23,676,106 tons of steel ingots and castings for the year and which presented the curious spectacle of "the production of steel" exceeding the production of pig iron, for only 23,649,547 tons of pig iron was produced in the year. The item included 646,627 tons of steel castings, leaving the steel ingot production at 23,029,479 tons, from which 17,578,556 tons of rolled steel was produced, 23.6 per cent disappearing, which has been approximately the average in recent years. It is not lost material, since the great bulk passes to the open-hearth furnace and therefore appearing again in the ingot figures.

Without going into minute details, it may be observed that, irrespective of the ups and downs in the total of rolled steel produced in recent years, there has been a great change in the analysis. A smaller proportion than formerly of the total is made up of the heavy products, the lighter products being correspondingly more in evidence. The production of sheets in various forms has increased very strikingly, and particularly for the electrical, automobile and tin plate industries. Wire rods have shown remarkable gains, the rod production being 47 per cent. as great as the rail tonnage in 1906, but 87 per cent as great in 1911.

Detroit Meeting of the American Institute of Chemical Engineers.

The fifth annual meeting of the American Institute of Chemical Engineers will be held in Detroit, Mich., from Wednesday to Saturday, December 4 to 7, 1912. Headquarters will be at the Hotel Cadillac.

The meeting will be opened on the morning of December 4, at the Hotel Cadillac, with an address of welcome by Hon. Homer Warren and a business session, which will be followed by a session starting at 11 a. m. for reading and discussion of the following four papers: Prof. E. E. Ware, on changing rate of setting Portland cement; Mr. Wm. M. Booth, on industrial efficiency and Mr. David L. Davoll, Jr., on technical accounting and chemical control in sugar manufacture. In the afternoon a visit will be paid to the works of Park, Davis & Company.

In the evening of the same day Dr. L. H. Baekeland will deliver his presidential address on the protection of intellectual property in relation to chemical industry. This will be followed by a paper by Prof. A. E. White on availability of blast furnace slag as a material for making brick. This meeting will also be held at the Hotel Cadillac.

During Thursday, December 5, a number of excursions will be made to the plants of the Ford Motor Company, the Acme White Lead & Color Company, and the Pennsylvania Salt Manufacturing Company. Arrangements for automobiles have been made by the Society of Detroit Chemists and the local committee to take members of the Institute and their guests to these plants. In the evening of Thursday a subscription dinner will be held at the Hotel Cadillac.

On Friday morning the members will be taken by special train, leaving Detroit at 8:15, to Ann Arbor, Mich., where the laboratories and buildings of the University of Michigan will be inspected. After luncheon there will be a session devoted to the reading and discussion of the following papers: Prof. M. C. Whitaker, on the chemical engineering laboratory of Columbia University; Prof. Robt. K. Duncan, on industrial fellowships; Dr. G. W. Thompson, on tests on the opacity and hiding power of pigments, and Dr. Edward Gudeman, on composition of glucose and starch sugars.

After this meeting is over a special train will take the members back to Detroit where an evening session will be held at the Hotel Cadillac at 8 p. m. for the reading and discussion of the following papers: Prof. J. H. James, on solvents for acetylene; Chas. A. Newhall, on rotary kiln lining for burning Portland cement, clinker of unusual composition, and S. F. Peckham, on the bituminous rocks of the United States and their use for street surfaces. This will be followed by the final business session.

For Saturday, December 7, visits have been arranged to the following plants: Berry Bros. Ltd.; Detroit Sulphite Fibre Company; Detroit Copper and Brass Rolling Mills, and Michigan Malleable Company.

Dr. L. H. Baekeland is the president of the Institute and Prof. J. C. Olsen, Polytechnic Institute, Brooklyn, N. Y., is the secretary.

The " Destruction of Niagara Falls."

In the editorial "Two Aspects of Conservation" in our International Congress issue of September 12 reference was made to the deplorable cessation of power development at Niagara Falls, due to the international agreement entered into by the United States and Great Britain for the sake of "saving the beauty of the falls."

These remarks have been the subject of some comment in the *Literary Digest* where it is said that "some of us may think that too much of the water is already used for the generation of power."

The New York *Evening Sun* of October 25 replies to this suggestion on its always interesting and instructive editorial page—certainly one of the best editorial pages of New York newspapers—as follows:

"If any do think so, it must be, as we intimated, those of us who have never been there and have to depend on the fables of travelers. Father Hennepin in the seventeenth century described the fall as 'a great and prodigious cadence of water to which the universe does not offer a parallel.' He guessed it to be more than 600 ft. high—about four times the real height. 'The waters,' he wrote, 'which fall from this great precipice do foam and boil in the most astonishing manner, making a noise more terrible than that of thunder. When the wind blows to the south its frightful roaring may be heard for more than fifteen leagues.'

"Another enthusiastic traveler of the same period did not think enough had been made of the scene, and boldly estimated the height at 800 ft. A third was content to describe it vaguely as 'a cataract of frightful height.' Father Hennepin made a remarkable drawing of what he saw, which, as John Tyndall observed, 'shows that serious changes have taken place since his time.' There have been similar serious changes since the development of power began, and they may be as easily accounted for.

"The damage done by the engineers can only be detected by those who have never been near Niagara Falls."

In the issue of November 4th of the New York *Evening Sun* this subject is again taken up editorially. With reference to the remarks of Dr. Louis Bell in our November issue, page 714, on the sociological aspect of electric power distribution over a wide area, these remarks are made by the *Evening Sun*:

"To those who are inclined to dismiss these social considerations as impertinent and still insist on sticking to the single point of the spectacle, it may be retorted that their concern for the scenery is not impressive while they fasten on the power question alone and neglect other points of more moment.

"Only the other day we came across an item in one of the local papers describing a novel project for 'beautifying' the country about the falls. This included the construction of some new inclined railways in the glen, besides 'an aerial tramway across the whirlpool from point to point on the Canadian side, which would soon become famous as a thriller of the first magnitude and an attraction to the million or two of tourists visiting Niagara annually that would rival all other scenic features combined.' This will be followed, no doubt, by further proposals for brightening and prettifying Foster's Flats, one of the beautiful spots that have not as yet been ruined.

"The development of power is insignificant as a destroyer in comparison with the development of 'scenic features' and 'thrillers' for the tripper."

The Western Metallurgical Field.

End of Labor Troubles in Utah and Nevada.

The labor strike which was called by the Western Federation of Miners at Bingham, Utah, and which later spread to Garfield, Utah, and Ely and McGill, Nev., has been practically ended. The strike failed of its ultimate purpose, which was the recognition of the miners' union by the mining and milling companies at the places mentioned. All miners in the Bingham district were called out on strike on the morning of Sept. 18, and the disturbance continued throughout September and most of October. In addition to recognition of the union in dealing with employees, the Federation demanded a flat increase in wages of 50 cents per day.

The Utah Copper Company, the largest company operating at Bingham, steadfastly refused to have any dealings with the Federation, and, together with other companies in the same district, proceeded to import men to work in its mines and mills.

The proceeding was accompanied with a few acts of violence resulting from clashes between the strikers, strikebreakers and deputy sheriffs, and several men on each side were wounded.

For a short time the strike effectually prevented any mining operations, and as a result the large mills of the Utah Copper Company at Garfield, Utah, were forced to suspend operations. The labor disaffection spread also to the smelters of the Garfield Smelting Company, at Garfield, and the International Smelting & Refining Company, at Tooele, Utah, the men at the latter places striking in sympathy with the miners, but not in sufficient number to be effective.

Believing that many of the foreign laborers were coerced and deceived into supporting the strike, the mining companies made every preparation to protect such men as wished to work, and ultimately succeeded in resuming operations, so that by the latter part of October the mines and mills were again running at nearly full capacity. On Nov. 1 the Utah Copper Company voluntarily posted a notice of increase in wages, ranging from 25 cents per day downward, according to class of labor, and effective as long as the price of copper remained at 17 cents per pound or over. In dealing with the strike situation no negotiations were had with the Western Federation of Miners, and in resuming operations no concessions were made to that organization.

In Nevada the situation was rather more critical, being accompanied with several fatalities resulting from conflicts between the strikers and deputy sheriffs. At one time Governor Oddie felt called upon to declare martial law at Ely and McGill, and called out the state police to preserve order. He offered his services as an intermediary between the Nevada Consolidated Copper Company and the strikers, but this was declined by the manager for the company, who announced that the re-employment of men and the rate of pay for labor would be based wholly on efficient service. The company had no objection to its men belonging to the union, but insisted that its operations should not be interfered with by persons outside its employ. The company was forced to suspend mining operations from Oct. 2 to 24, and the concentrator also was idle a part of the time, but by this time the mines and mill are again running at nearly full capacity. A voluntary increase in pay was announced by the company, similar to that in force at Bingham.

A significant incident of the strike was the refusal of the Butte miners to contribute a large sum of money, said to be $28,000, to the support of the Utah and Nevada strike.

Changes at Butte & Superior.

Some changes in the concentrating system at the Butte & Superior zinc concentrator, at Butte, are now under way and probably will be completed early in December. Garfield roughing tables, which have proved so successful in the copper concentrators in Utah and Arizona, are being installed in place of about twenty jigs. The table tailings will be reground and treated in jigs, and the rough concentrates will be retreated on other tables. Experiments have indicated that a better saving will be effected by this change. The capacity of the concentrator is being increased by the construction of a wing in which additional machinery will be placed. An extension of the flotation department also is planned, and the combined changes will raise the capacity of the plant to 2000 tons per day. At present the mill is running only at half capacity, treating ore containing about 16 per cent zinc and yielding tailings of 4 per cent zinc. Mining operations are being extended so that the increased capacity of the mill will be cared for by the time the changes are completed.

Work of the Mason Valley Copper Smelter.

The Mason Valley Mines Company, operating copper mines and a smelter at Thompson, Nev., has made public some figures on the work of the smelter. Forty per cent of the ore now treated comes from the company's own mines, and the balance is custom ore from mines in the district. In the period from Oct. 7 to 14, inclusive, No. 2 furnace smelted 8155 tons of charge, of which 7289 tons were ore. The operation produced 531 tons of matte containing 449,438 lb. copper, equivalent to an annual production of 20,000,000 lb. copper. The daily charge averaged 1019 tons; daily matte production, 66.3 tons, averaging 42.32 per cent copper.

Among the custom shippers to the Mason Valley smelter are the Nevada Douglas, Yerington Malachite, New Yerington, and others of minor importance. In harmony with the action of other copper producing companies, the Mason Valley has announced an increase in wages of 25 cents per day, effective Oct. 1, and in force as long as the present high price of copper prevails.

Jumbo Extension Mill, Nevada.

The Bonnie Clare Mill, south of Goldfield, Nev., is being used to treat the ores from the Jumbo Extension, which adjoins the Goldfield Consolidated. At present the operation consists solely of concentration after crushing with stamps, as it has been demonstrated that this process will recover 80 per cent of the valuable mineral. The mill is equipped with cyaniding machinery which can be used on the tailings whenever necessary. Manager E. S. Van Dyck is authority for the statement that the stamps are crushing an average of 5.7 tons of ore per stamp. The ore has an assay value of from $12 to $42 per ton, averaging about $20. The tailings from concentration assay from $1.20 to $1.60 per ton, and are not considered worth further treatment by cyaniding. Deister sand and slime tables and vanners are used for concentration, and are giving satisfactory results. The present capacity of the plant is only 60 tons per day, but the addition of more tables will bring the capacity up to the expected standard of 100 tons per day.

Company Reports.

Stratton's Independence, Ltd., has issued the fourth annual report on the operation of its mine and mill in the Cripple Creek district, Colorado. The report covers the fiscal year ended June 30, 1912. The following table shows the crude ore treated at the mill:

	Dump Ore, Tons.	Mine Ore, Tons.	Total Tons.	Oz. Gold per Ton	Total Ounces.
Fiscal year	99,373	13,019	112,392	0.155	17,428
Previous year	102,364	7,436	109,800	0.157	17,289

The total recovery amounted to 73.63 per cent of the gross value of the ore, as compared to 71.5 per cent in the previous year. The recovery by concentration amounted to 42.19 per cent and by cyanidation 31.44 per cent, as compared with 43.65 per cent and 27.85 per cent, respectively, in the previous year.

The cost of milling begins with coarse breaking, for which there is a plant at the mine for mine ores and another for dump ores. Following is the cost per ton for the various milling operations:

	Cost per Ton.
Coarse crushing	$0.1694
Fine crushing and concentrating	0.4938
Cyaniding and special chemicals	0.4866
Miscellaneous	0.1211
Total cost	$1.2709

The first-grade concentrate had an average content of 4.34 oz. gold per ton, and the second grade 1.35 oz. per ton. The high-grade concentrate amounted to 82.44 per cent of the total concentrates produced. All concentrates were sold to the smelter, where the treatment cost amounted to $0.137 per ton of crude ore concentrated.

The total cost of all operations, including mining, milling, and treating concentrate was $1.50 per ton of ore treated.

On account of the severe winter of 1911-12 the mill was forced to suspend operations from Dec. 22 to Jan. 17. The expense incurred during this time, and the reduced tonnage of ore treated, increased the expense materially. Deducting this

extraordinary expense, the cost of milling for the year is only $1.24 per ton. In March, 1912, the lowest milling cost was reached, when 10,491 tons of ore was treated at a cost of $1.16 per ton. The year has been successful, on the whole, and the outlook for the future is considered good. The directors declared an interim dividend of 10 per cent free of income tax on Nov. 9.

The Utah Copper Company has issued a report for the third quarter of 1912. Operations were affected by the labor disturbances, as detailed above. The September tonnage fell from over 11,000 tons to about 7000. The total ore treated during the quarter was 1,581,527 tons, of which the Magna plant treated 62 per cent and the Arthur plant 38 per cent. The average assay of the ore was 1.41 per cent copper and the cost per pound of net copper produced was 7.707 cents after making allowances for smelter deductions, but without crediting miscellaneous income. Crediting the latter, the cost was only 7.017 cents.

Excepting during labor disturbances, the Magna plant was in operation full time. The Arthur plant is now remodeled and ready for full production, the thirteenth and last section of the mill having been completed in September. The company announces that it has made arrangements for the purchase of electric power, which will render unnecessary the extension of the steam power plant at the Magna mill.

The report of the **Nevada Hills** company for September has just been issued, from which it appears that during this period the mill handled the largest tonnage in its history. The total ore milled amounted to 3386 tons, of an average gross value of $23.13. The loss in the tailings was $2.02 per ton of ore, leaving a net recovery of $21.11 per ton. The cost of mill was $8.36 per ton, giving a net profit of $12.75 per ton. The total recovery was 91.2 per cent, of which concentration contributed 22.6 per cent and cyaniding 68.6 per cent. The cost of labor per ton of ore milled was $0.93; of marketing the concentrate, $0.64 per ton, and of marketing cyaniding bullion, $0.30 per ton.

Talbot Process for Improving Soundness in Ingots.

In an editorial in our last issue we referred to the new Talbot process for improving the soundness of steel ingots as made known at the last meeting of the (British) Iron and Steel Institute. Further details of the process were given by Mr. **Benjamin Talbot** himself at a special informal meeting held on November 7 in New York City under the auspices of the Iron and Steel Section of the American Institute of Mining Engineers. Mr. Charles Kirchhoff presided and Mr. Bradley Stoughton acted as secretary.

After some introductory remarks on the problem of segregation and cavities in steel ingots, and on the effect of the size of the ingot, and the unfavorable effect which large ladle heats of 100 tons have, Mr. Talbot took up the importance of the deoxidizer needed to eliminate blow-holes.

"Sound ingots as regards the elimination of blow-holes are produced by means of the well-known powerful deoxidizers, aluminium, silicon, and ferrotitanium. All the deoxidizers have the same effect, when used in the necessary varying quantities to produce this. They all produce solid steel except for the large central cavity. They all diminish segregation. In my experience I have found with well-made steel that an addition of 2 oz. to the ton of aluminium is equal to 0.25 per cent of added silicon, and an addition of 0.10 per cent of metallic titanium in the form of ferrotitanium. These additions will all produce the same characteristic central pipe, and if they are used this piped portion should be discarded in each case."

It occurred to Mr. Talbot "that if we were to use a deoxidizer such as aluminium to eliminate blow-holes in the outer envelope of the ingot and then reduce the area of the ingot or the top portion, while the center was liquid, the pipe would not form and a solid mass would be found in the body of the squeezed ingot.

"In analyzing and taking sulphur prints off the face of the compressed ingot, which was cut longitudinally through its center, I came across an interesting discovery. I found that whenever an ingot was compressed while its center was liquid, no segregation formed in the center of the upper part as is usual, but that it was driven to the internal face of the solid envelope in fairly regular percentage over the entire length of the liquid area. The solid outer envelope is the normal steel of the heat and is about 3 in. The carbon in this portion in this case is from 0.65 to 0.70; the carbon in the harder portion next this is from 0.75 to 0.80, and in the center about 0.50. The sulphur and phosphorus also vary in these strata, but as the phosphorus is low in this steel it was not of sufficient amount to be considered.

"In ingots compressed while their center is liquid without the use of a deoxidizer, I find that the center shrinkage cavity is not formed, but that the blow-holes, which are found in the outer envelope, are not obliterated and can be traced into the rail. For this reason I prefer to use a deoxidizer so as not to have any surface blow-holes, which tend to give spongy rails.

"The method of procedure is as follows: An ingot of at least 20 x 24 in. in cross section is used; 2 oz. of aluminium to the ton of steel is added to the ingot as it is being poured. Aluminium is preferred because of its low cost and its low melting-point. It causes a perfectly solid outer envelope to be formed, and solidifies the metal earlier than if no deoxidizer were used. The ingot therefore can be stripped earlier, and it is then put into the soaking pit to allow the envelope to become thicker, and at the same time have a proper temperature upon its surface for compression. A 20 x 24 in. ingot is reduced to about 18 x 18 in., and it is then returned to the soaking-pit for a proper heating and solidifying of the mass. After this has been accomplished, it is rolled down into a bloom, cropped and passed to the rail-mill. The rail produced has the same characteristic formation as the squeezed ingot, viz., a hard working-face, harder ring at back of this and softer center.

"It is the question of this new formation that we manufacturers have to discuss with railroad engineers and metallurgists."

There was a long and animated discussion in which Messrs. H. M. Howe, H. D. Hibbard, A. A. Stevenson, E. F. Kenney, P. H. Dudley, Charles Kirchhoff, W. C. Cushing, M. H. Wickhorst, Bradley Stoughton, and W. R. Walker participated. The letter stated that the United States Steel Corporation would make a trial of the process.

Mr. Talbot is the inventor of the Talbot continuous open-hearth steel process which he developed while connected with the Pencoyd Iron Works in Philadelphia.

Meeting of the American Iron & Steel Institute.

The third general meeting of the American Iron and Steel Institute was held in Pittsburgh, Pa., on Friday, October 25th. The attendance was 375. That is practically one-half of the membership.

Judge E. H. Gary, in his presidential address, delivered in the morning, spoke of Pittsburgh as a steel center and of the most gratifying conditions and the era of prosperity now existing in the steel industry. "These conditions have not resulted from the application of political policies or efforts, but exist in spite of them." After pointing out the importance of the technical problems which were to be discussed at the meeting he referred to more important subjects and questions which must be solved and which involve the welfare of everyone. "The thought I would leave with you is that there is no way of permanently settling any great question involving the welfare of human kind except on the basis of right and justice.

Position, welfare, influence, laws are helpless as a means of establishing a rule for human conduct unless supported by principles of justice and righteousness." The following four papers were then presented during the morning session:

The Buyer from the Manufacturer's Standpoint, by John L. Haines.

Technical Training for Steel Salesmen, by James M. Camp.

The Use of Mayari Iron in Foundry Mixtures, by Quincy Bent.

The Manufacture of Ordnance at the Bethlehem Steel Works, by E. C. Grace.

After a buffet luncheon had been served the following papers were presented during the afternoon session:

Coal Mine Ventilation in the Connellsville Coke Region, by Austin King.

Recent Developments in the Preparation of Iron Ores, by J. W. H. Hamilton.

Microscopic Analysis of Steel Sheets, by C. Arthur White.

Electric Power Production and Distribution in Steel Works, by Stewart C. Coey.

The dinner in the evening was exceedingly enjoyable. A feature of it was an exceedingly interesting moving picture show "from iron mine to molder," by Rogers, Brown & Company.

The Spring meeting will be held in New York City as is the custom of the Institute. For the Autumn meeting it is possible that Birmingham, Ala., may be selected to pay a tribute to the developments of iron and steel manufacture in the South.

The Iron and Steel Market.

The conduct of the iron and steel market in November has been phenomenal. It has gained rather than lost strength, and at a period in the year when to gain strength has hitherto always meant to establish the character of business in the coming year as particularly good. The improvement has, moreover, been in the face of a sweeping Democratic victory at the quadrennial election, with assurance of radical tariff revision next summer. The steel trade, it should be noted, does not greatly fear tariff revision for its direct effect. It fears, rather, the depressing effect upon general business which radical downward revision of the tariff is quite generally held to promise.

The ordinary observer regards the demand for steel as exceptionally heavy for, not accustomed to quantitative conceptions, he measures demand simply in terms of capacity, failing to allow for the accepted fact that if demand is but slightly under the productive capacity all buyers pursue the most conservative course, buying only from hand to mouth and making no forward commitments, while if demand slightly exceeds capacity the buyer piles orders upon the mills and observing that they are filled up buys farther and farther ahead. A small difference in the actual consumptive requirements develops a very great difference in the amount of business which is offered to the mills. It needs only that consumptive requirements slightly exceed productive capacity, or sometimes the mere fear on the part of buyers that they will not be able to secure desired deliveries, to fill mills with business many months ahead. Sometimes the business on books proves substantial, and sometimes it proves quite otherwise. The condition of mills being filled with business far ahead does not establish it as a fact that demand is abnormally heavy, for it is merely the relation between productive capacity and demand which produces the condition. For half a century or more, up to 1907, the production of pig iron in the United States doubled on an average once in ten years, and the same statement can be made as to rolled iron and steel for the shorter period in which complete statistics have been gathered. Adopting this rule and using the figures of 1905-6-7 as a basis, a tonnage is found for the present time quite in excess of the productive capacity. To denominate the present demand as exceptional is to assert that

it is known the rule of increase broke down a few years ago, which would be absurd since it is much more rational to judge the rule by the actual developments. On this basis the inference is rather that the increase in productive capacity has been abnormally small in very recent years. So much was said in 1908, when demand was very light and the trade was committed to a heavy new construction program, about capacity having outrun demand, requiring a period of years for a readjustment to be effected, that the memory remains while it is not recognized that the period of years has really elapsed. In 1906 the production of pig iron was 25,300,000 gross tons and the production of finished rolled iron and steel 19,600,000 gross tons, and the rule of doubling in ten years would require a production 41.6 per cent. greater in 1911, or 35,800,000 tons of pig iron and 27,800,000 tons of rolled iron and steel. More than a year after the middle of 1911, however, the average rate of pig iron production is not more than 32,000,000 tons, with rolled iron and steel being produced at the rate of about 26,000,000 tons, while the demand apparently outruns the capacity. Such increase in production as has occurred is not all in material available for the domestic market, for exports in 1906 were 1,300,000 tons, which with a 41.6 per cent increase would be 1,850,000 tons for this year, when the actual rate of export is 3,000,000 tons.

The reasonable inference, therefore, is not that the present demand is exceptional, but that productive capacity has failed to increase in accordance with requirements.

It should be observed, however, that in the past demand has not increased uniformly, and it is only by averaging periods of years that a law can be developed. In studying the present conditions attention should therefore be directed to all sources from which information can be obtained to aid in forming a judgment.

One special definite cause of heavier consumptive demand at this time is that railroad expenditures have greatly increased, based partly upon the very favorable earnings in the past few months and partly upon the certainty of heavy earnings at this time and until the end of the crop moving period. In purchases of material for specific purposes in November railroad buying was by far the most prominent. There was little of buying against large structural operations, but a great deal of contracting by jobbers and also by ordinary manufacturing consumers.

Such business proves trustworthy if general business conditions continue good, and not otherwise.

On Tuesday, November 19, one of the Cleveland ore firms announced prices on Lake Superior ores for the season of 1913, stating at the same time that it had effected some sales. The prices thus announced have been accepted by ore sellers as the regular basis. They are as follows, for ore delivered Lake Erie docks, 55 per cent iron content, natural state, with 10 per cent moisture, for Bessemer ores, and 51.50 per cent iron content, natural state, with 12 per cent moisture, for non-Bessemer ores:

Old range Bessemer	$4.40
Old range non-Bessemer	3.60
Mesabi Bessemer	4.15
Mesabi non-Bessemer	3.40

These prices are precisely 10 cents below the 1911 schedule, and 65 cents in the case of Bessemer and 55 cents in the case of non-Bessemer, above the nominal prices for 1912, the market having been rather unsteady during the year. The 1911 schedule, which is so closely approached, was identical with that of 1908 and 1909, but 50 cents below that for 1907 and 1910.

The early opening of the selling season is an evidence of strength in the general iron and steel market and is with one exception the earliest for at least a quarter century.

Pig Iron.

Pig iron prices trended upwards during November, but much less so than in October. Sales of foundry grades were lighter,

but were quite heavy in the case of Bessemer and basic in the Central West, chiefly for delivery in the early months of next year. Connellsville coke ruled at about $4 a ton for prompt shipment, while on contract for first half the market advanced to $3.25 and $3.50, according to grade. The advances in coke and ore absorb the greater part of the advance in pig iron which has occurred in this entire movement, and furnaces will perhaps endeavor to secure further advances in pig iron, based upon the advance in ore for next season, but the relation between ore and pig iron prices is frequently lost. It is significant, for instance, that the 1912 ore prices were announced last March, with reductions of 65 to 75 cents, whereas it was at that very time that pig iron began the real upward movement. The market is now quotable as follows: Bessemer, $17.25; basic, $16.50; No. 2 foundry, $17.25 to $17.50; forge, $16.75 to $17; malleable, $17 to $17.25, f.o.b. valley furnaces, 90 cents higher delivered Pittsburgh; No. 2X foundry, delivered Philadelphia, $18.25 to $18.50; No. 2 foundry, f.o.b. Chicago furnaces, $18; No. 2 foundry, Birmingham, **$14 to $14.50.**

Steel.

There are no regular sellers of steel billets and sheet bars, mills being well sold up for months, and a number of finishing mills appear to be left with an insufficient amount of steel under contract for the first quarter. The market can only be quoted approximately, prices being largely nominal: Bessemer billets, $27; sheet bars, $27.50; open-hearth billets, $28; sheet bars, $28.50; rods, $30, f.o.b. maker's mill, Pittsburgh or Youngstown.

Finished Steel.

There are two markets, one at which the large mills will accept business for far forward delivery and the other a market made by smaller independent mills which can make earlier deliveries. Regular prices for forward delivery are given below, prices being f.o.b. Pittsburgh unless otherwise stated:

Rails, standard sections, 1.25 cents for Bessemer, 1.34 cents for open-hearth, f.o.b. mill except Colorado.

Plates, tank quality, 1.50 cents.

Shapes, 1.50 cents.

Steel bars, 1.40 cents.

Common iron bars, 1.65 to 1.75 cents, Pittsburgh; delivered Philadelphia, 1.67½ to 1.75 cents; f.o.b. Chicago, 1.60 to 1.65 cents.

Steel hoops, 1.50 cents.

Sheets, blue annealed, 10 gage, 1.65 to 1.75 cents; black, 28 gage, 2.25 to 2.35 cents; galvanized, 28 gage, 3.40 to 3.50 cents; painted corrugated, 28 gage, 2.45 cents; galvanized, 3.45 cents.

Tin plates, $3.60 for 100-pound cokes.

Merchant steel pipe, ¾ to 3-in. jobbers' carloads, 79 per cent off list.

Steel boiler tubes, 3½ to 4½-in., 72 per cent off list.

Standard railroad spikes, 1.85 to 1.90 cents.

Button head structural rivets, 2.10 cents; cone head boiler rivets, 2.20 cents.

The Non-Ferrous Metal Market.

The non-ferrous metal market has been rather quiet since our last report, with slightly receding prices for some of the metals, notably lead and spelter. Demand has been only moderate and there has been an evident desire on the part of producers to make prices which would force sales.

Copper.—The market has been dull, and while the principal agencies have maintained their prices, it is known that considerable business in electrolytic has been effected by shading the quoted prices. The latest available quotations are 17½ @ 17¾ cents for Lake copper and 17.35@17.45 cents for electrolytic.

Tin.—The foreign market remained firm early in November, but weakened about the middle of the month, due to large Straits shipments. Domestic sellers have made inducements to effect sales, and November tin is quoted at 50 cents.

Lead.—Although the A. S. & R. Co. has maintained its price of 5.10 cents, business has been done at lower figures owing to offerings of western lead at lower prices. The market has been rather dull and weak. New York quotations are 4.62½@4.67½ cents, with St. Louis at 4.47½@4.52½ cents.

Spelter.—Prices have tended to decline slightly on account of the dullness of the market, but there was an upward tendency about the middle of November, particularly for spelter for early delivery. The latest quotations are 7.25@7.30 cents, St. Louis, and 7.40@7.45 cents, New York.

Other Metals.—Prices for aluminium are not quite so firm, quotations at New York being about 27 cents per lb. The antimony market is quiet but firm, quotations ranging from 9¼ to 10⅜ cents for various grades. Business in quicksilver has been good with steady prices at New York. The metal is quoted at $42 per flask of 75 lb. at New York, and $41.50 for domestic orders at San Francisco and $39 for shipment to foreign countries.

CORRESPONDENCE.

Troostite.

To the Editor of Metallurgical and Chemical Engineering:

SIR:—I regret that the article on troostite in your April issue had hitherto escaped my attention. Since its writer has most distinctly misread my paper[1] which he quotes, it seems desirable if you will kindly grant me a little space, to correct his error, which will then enable me to show that the views I then stated are in accordance with all the latest accepted theory. The fact is that in my paper I was endeavoring to show that Boynton had made certain errors, and Boynton has since admitted that his conclusions were erroneous. I was guilty of indulging in a gentle sarcasm, and it was this which was misunderstood by Bullens, as it was by Benedicks in 1905.[2] In the case of Benedicks one might plead that the paper was not in his language.

I actually gave my opinnion (p. 486, loc. cit.) as follows: that troostite is "a mixture, fairly intimate, but not so much so as is solution, of ferrite or cementite with a solid solution of the two. In the case of medium carbon steels . . . troostite would probably consist of such a mixture of ferrite and solid solution." The gentle sarcasm was in my remark on p. 485: "The writer fails to see why it (troostite) should be β iron rather than γ." I will now fill this remark in so that it can surely no longer remain ambiguous. It should then read: "All of Boynton's arguments would apply equally well to prove that troostite is γ iron, as to prove that it is β iron; this would be so obviously absurd that neither Boynton nor anyone else would for a moment advance such a theory."

Troostite is such an important constituent to all metallographers who "acquired the habit" of metallography before the innovations in nomenclature that I feel this is sufficient apology for again opening this very live subject.

F. ROGERS.

Sheffield, England.

"Exothermic" Steel.

To the Editor of Metallurgical and Chemical Engineering:

SIR: Mr. Amsler in your November issue says in his letter that: "If any critic will submit a better chemical explanation of the matter than the one given it will be thankfully acknowledged;" also that: "Constructive criticism will be welcomed." I accept both invitations.

In the original article on "Exothermic Steel" in your September issue it is stated that: "A quantity of iron ore and flux was mixed in a No. 4 graphite crucible, which was then placed in an ordinary cast-iron 'cannon-ball' stove and well

(1) Iron and Steel Institute Journal, 1905, 1, pp. 484-486.
(2) Ibid., 1905, 2, p. 363.

packed in coal. After about fifty minutes the crucible was removed to find the molten iron separated out under a cover of fluid vitreous slag." The flux referred to was feldspar, bauxite and limestone with no carbon, and the experiment is supposed to prove the *reducing* action of this flux. I have already characterized this supposition as unbelievable. I prefer to believe that the carbon of the graphite crucible containing the mixture is one reducing agent which Mr. Amsler has ignored and the white-hot carbon monoxide atmosphere in which the crucible is immersed (it was "well packed in coal") provides another reducing agent which must not be overlooked. These two supply all the reducing action necessary to explain the reduction of the iron ore without assuming in regard to feldspar flux that it acts reducingly and exothermally like free aluminium.

Since "matte" is a melted sulphide, mostly of copper and iron, Mr. Amsler should not use this term for an entirely different product. He should at once abandon the term "matte" in connection with his furnace, because he has no right to use it as he does. Let me suggest as a more appropriate name, "smelting" furnace, and for the product, "sponge." These may not be acceptable to Mr. Amsler, but he owes it to his standing as a metallurgist to drop at once his misuse of the term "matte."

As to the product, it certainly looks like "good stuff"; so good that it is a pity it should have had such a misnomer as "Exothermic Steel" tagged on to it and also a greater pity that it should have been heralded by such a sorry apology for a scientific explanation of its reason to exist. I herewith offer the only one which at present appears to me as reasonable, namely, that good ore is used and pure fuel and that the cleansing influence of a rather expensive but very efficient feldspar flux is responsible for the rest. I believe that a light, fluid, clean slag, capable of absorbing and holding the various metallic oxides and compounds which usually contaminate the fluid steel may have very striking effects on the quality of the metal. I think that any open-hearth steel would be improved by using some feldspar flux just as it is known to be improved by using fluorspar.

If anyone has better explanations than those offered above I shall be interested to hear them.   Jos. W. RICHARDS.
Lehigh University.

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To the Editor of Metallurgical and Chemical Engineering:
SIR:—In Vol. X, No. 9, page 559, of this journal W. O. Amsler, D.Sc., published an article on "exothermic steel" which was very interesting and suggestive. In the article it was stated that even tungstic acid could be reduced to metallic tungsten by means of this process, whereby a great saving of power might be obtained.

The present writer has had the opportunity of testing this statement on a laboratory scale, and although the result was negative, it may be of interest to relate the test since negative results are, in a way, very instructive and a report of the same may also lead to a very valuable discussion, in as much as it may be shown why a result is a negative one.

According to the chemical equation for iron, as given in the article mentioned, a corresponding equation for WO_3 was drawn up and the following mixture prepared, using a tungsten ore containing 72 per cent of WO_3 and some calcium oxide, silicate, etc., which was all considered in making up the charge. The charge consisted of:

Ore	100 lb.
Feldspar (potassium)	132 lb.
Bauxite	60 lb.
Lime	10 lb.
Carbon	4 lb.
Iron	6 lb.

This would give approximately 60 lb. of alloy containing 80 per cent of tungsten, taking losses into account.

The mixture was gradually charged into a well burnt laboratory electric furnace with one floating and one bottom electrode, fed with alternating current in the usual way. A thick "sticky" slag was obtained, which proved to be very vitreous after cooling, showing the appearance of an impure glass.

Altogether 210 kw-hours were required to melt down the whole charge, and judging from the "boiling" the reaction was expected to take place. When the "boil" subsided, after the whole of the charge had been melted, the mass was left to "soak" for some time, allowing the temperature to rise considerably.

The top layer of slag was drawn off and the remainder was left in the furnace to cool.

After cooling, the mass was broken out and examined. Altogether about 280 lb. of slag was obtained, and a cake of fused semi-metallic substance, weighing 59 lb. This was found to contain on an average 50 per cent of metallic tungsten, while the slag contained 9.9 per cent of W.

In the whole 56.6 lb. of W were charged into the furnace; 29.5 lb. were recovered as a semi-metal while the rest, or 27.1 lb., were lost in the slag, showing an actual loss of 48.2 per cent.

It shall not be said on account of this meagre result that the method is a fallacy; it is quite possible that if the process is more carefully studied a more promising result may be obtained, and it should be of great interest to have the test criticised, and modifications suggested. This much shall be said, however:

The amount of feldspar and also of bauxite required, according to the equation, is very considerable and will of necessity create a large amount of slag, which is bound to take up a considerable quantity of metal under all conditions, even if the actual analysis shows a fairly low figure of percentage.

Furthermore, the heat expected to develop from the reaction itself is not realized in practice; if one has to spend as much as 210 kw-hours to obtain about 30 lb. of tungsten, very little is gained in this respect, more so as it was fully evident that still much more heat would have been required to cause a complete reaction and separation, if such were possible.

The cost of especially the feldspar, and also to some extent of the pure ground bauxite, is far too high to compensate for this, when it is considered that the ordinary reaction with carbon (coke or graphite) only as a reducing agent hardly requires more, but rather less power and produces infinitely less slag.

It will, however, be of interest to criticise the statement from a chemical point of view. The author of the article mentioned (page 559) writes the formula for the iron oxide reaction as follows:

$$Fe_2O_3 + 2K\,Al_2\,Si_5O_8 + 2Al_2O\,(O\,H)_4 + CaO =$$
$$2Fe + 4Al_2O_3\,6SiO_2\,2KOH\,CaO + 3H_2O.$$
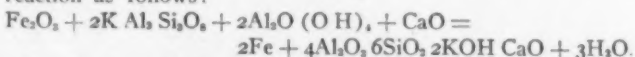
In the first place, the expression 2KOH is evidently an error, as it is not likely that this highly vitreous slag should contain any H_2O; it should rather read $K_2O + 4H_2O$. This, of course, may be only an oversight in writing it down.

The formula given for the feldspar, however, is open to a more serious consideration. The definition of a true feldspar, as given in all handbooks and as borne out by chemical reasoning, contains one monoxide, one alumina and two to six molecules of SiO_2. Consequently the expression for feldspar in the above equation should read ($K_2O\,Al_2O_3\,6SiO_2$) or by halving it as shown in the equation, it should be:

$$2(K\,Al\,Si_3O_8) \text{ and not } 2Al_2, \text{ etc.}$$
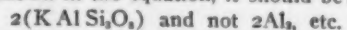
If we now write the equation out in this way

$$Fe_2O_3 + 2K\,Al\,Si_3O_8 + 2Al_2O\,(O.H)_4 + CaO$$
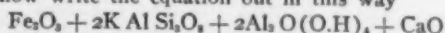
we find that there is no binder for the 3O in the Fe_2O_3. This has only been provided for in the original equation by writing

the feldspar $2(KAl_2Si_3O_8)$ thus introducing two extra atoms of Al, which, of course, would form Al_2O_3, if really present in practice.

If, however, the ordinary potassium-feldspar and the bauxite only are to be used, it seems that a reduction of the ore can only be effected through the carbon, which the author states "could" be introduced. In this case the spar and the bauxite are only slag-forming ballasts, and this would, of course, account for the unsatisfactory result obtained when the writer attempted to reduce the wolfram ore. The addition of metallic aluminium is not mentioned in the article.

It was fully evident that the reaction did not proceed of its own account after it had been heated to the ignition point by means of the electric arc, as would have been the case if free aluminium had been present.

The writer wishes to repeat, however, that there is plenty of room for explanations, which he hopes will be forthcoming, and that a single trial like the one described should not be considered conclusive: in the interest of general knowledge, however, the matter ought to be cleared up.

Luton, Beds, England. JOH. HÄRDÉN.

* * *

To the Editor of the Metallurgical & Chemical Engineering:

Sir: The time in which to reply to Professor Richards' recent and more courteous letter is too short to go into the matter as fully as I would like.

The object of the experiment of the number 4 graphite crucible was not, as Professor Richards says, to prove the reducing action of the flux so much as to prove the exothermic nature of the reaction. That carbon plays an important part in the reduction has not been and is not denied, but on the contrary it is considered an essential element. That packing of the graphite crucible in coal will produce a reducing atmosphere should be evident to any metallurgist without having it pointed out to him. However, the reducing atmosphere will not reduce ore and limestone under these conditions without the flux. Neither is it possible to melt steel scrap in the same reducing atmosphere. In fact, none of the ingredients of the charge taken by itself can be so melted. Yet the addition of the feldspar, bauxite and limestone to the ore will reduce the ore and produce a liquid steel which will pour as readily as water if it is not left in the stove too long after the reduction. If the metal is not poured promptly it will freeze in the bottom of the crucible. This same experiment has been made many times and has also been made with 50 per cent ferrotungsten.

I would suggest that Professor Richards make these experiments to satisfy himself. The actual demonstration is much more convincing than any amount of argument no matter how erudite. Whether the flux actually reduces the ore or whether it takes it up in a solution of vitreous slag so that the carbon, silicon or aluminium can act differently than they do in the usual processes, I will not undertake to say, but it undoubtedly does produce a reducing condition that is different and it undoubtedly is accompanied by a rise of temperature.

There seems to be considerable misapprehension as to the amount of flux required to produce the desired results. The amount of feldspar used is generally about one, and bauxite $\frac{1}{2}$ per cent of the weight of the ore. There must be a sufficient amount of carbon present to accomplish the reduction, as the amount of reduction accomplished by the flux is probably small. The chemical explanation made in the article was intended to apply only to that portion of the reduction not accomplished by the carbon.

In regard to the quantity of flux to be used, the figures given are for the practical operation on a large scale. For laboratory experiments, especially with the No. 4 graphite crucible, the quantity required is from ten to fifteen times that given.

It is immaterial to me what the product of the stack furnace is called so long as Prof. Richards and I understand each other when its name is used. I had selected the word "sponge," but changed it to "matte," as my idea of a sponge is a refined metal in a state of loose physical structure, whereas matte is a partially refined metal, a term applied, it is true, at present almost exclusively to copper, but I see no reason why it should not be broadened. The product of this stack furnace is undoubtedly a partially refined product, as it carries the metal and all slag, including any sulphur, copper, or other impurity that may get into the furnace and that is not taken out by the blast.

Experimenters must not expect the exothermic reaction to be as violent as that of the "thermit process." When the temperature of the charge reaches the critical stage the reaction will increase the temperature above that of the surrounding fire or furnace, but upon withdrawal of the support of this outside source of heat so that the temperature falls by radiation or otherwise the reaction will cease.

I have not yet had time to go fully into the rather long letter of Mr. Joh. Harden, but it seems that the amount of feldspar and bauxite used was nearly a hundred times too much.

Pittsburgh, Pa. WALTER O. AMSLER.

Proposed Code of Ethics of the American Institute of Chemical Engineers.

To the Editor of Metallurgical & Chemical Engineering:

Sir: I enclose an "Open Letter" to those who would impose a "Code of Ethics" on the American Institute of Chemical Engineers. Since the question at issue is of general interest, you may find it expedient to publish these views.

Dear Sirs: The fact that other engineering societies have adopted a "Code of Ethics" is not a satisfactory reason why the Institute of Chemical Engineers should adopt one. They may have made a bad mistake in adopting a code, and it would then be no credit to us to follow their example. Let us make our own mistakes, if we are going to make any, and not simply repeat the mistakes of others.

The Institute of Chemical Engineers was intended to be select, to contain only men of prominence and accomplishment in their profession. Its foundation was partly a protest against the indiscriminate character of the membership of the American Chemical Society, and because membership in that society conferred no distinction. Such being the high character of the membership of the Institute, it is unfitting and ill-advised to formulate "rules of conduct" for them, as if they were tyros in the art of being "an honest man and a gentleman."

The adoption of such a code would distinctly lower the dignity and distinction of membership in the Institute. It is, by assumption, unnecessary, because we elect as members only men who by action and achievement have shown themselves to be distinguished gentlemen. To prescribe to such, for example, that they shall "be guided by the highest principles of honor," is as unnecessary as it is silly and ridiculous; indeed, it is a gratuitous insult to every member of the Institute.

I do not hesitate to say, that if any member of the Institute has lost self-respect to such extent that he feels that he, himself, needs such a prescription as that just quoted, to keep him in the path of honor and rectitude, then he should be thoughtful enough to resign from the Institute before he brings discredit upon it. The Institute is not a reformatory.

Neither do I hesitate to say that any member who recognizes that he himself does not need such a prescription, but still would impose it on the Institute "for the benefit of his weaker brothers," is an unmitigated cad, and unfit to direct or influence the proceedings of the Institute.

I sincerely hope that the whole proposition will be voted "down and out" for good; every member who votes for it stultifies himself.

JOS. W. RICHARDS.

Lehigh University,
South Bethlehem, Pa.

The Effect of High Carbon on the Quality of Charcoal Iron

A Paper Presented at the Cleveland Meeting of the American Institute of Mining
Engineers by J. E. Johnson, Jr.

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To explain this qualitative importance and explain some of the factors that affect the quality are the objects of this paper.

The advent of coke iron, which transformed the whole iron industry commercially, left intact a limited production of char-

FIG. 1.—TESTING ARRANGEMENT.

coal iron in the East and South, which has been conducted always on the basis of high cost and high quality, with correspondingly high selling price. In the Northwest, particularly in the Lake Superior district, the development has been along totally different lines, for which the close proximity of the great iron ore deposits and the great forests of that region were responsible.

When the great white pine forests were removed there were left behind large areas of hardwood and hemlock, to which little attention was paid in the prosperous years of the white pine industry. But when the latter declined the demand for lumber and the presence of lumbermen, probably more skilled than any others in the world, caused the gradual introduction of these woods into commercial use.

It was a matter of ancient knowledge that hardwood made an excellent charcoal, and to utilize the cordwood left after the saw logs were removed by converting it into charcoal and using it to produce pig iron, with ore from the adjacent mines, was an obvious step.

In some cases the establishment of the furnace occurred independently of the lumbermen through common knowledge in the iron trade of the favorable conditions for a supply of raw material.

This outline is not intended to be historic in any other sense than as describing broadly the causes which produced a certain condition.

The abundant supply of both iron ore and hardwood made feasible the establishment of larger plants with greater outputs than prevailed at the Southern and Eastern ones, where there was generally a never-ending, life-and-death struggle for sufficient raw materials of both kinds to keep the operation alive.

Parallel with this development came that of the recovery of the by-products in the production of charcoal. First, methyl alcohol, commonly known as wood alcohol, and, secondarily, acetate of lime, from which are produced acetic acid and acetone. The varnish industry absorbed enormous quantities of both wood alcohol and acetone and this consumption steadily

grew. This caused the construction of wood carbonizing plants, of which the so-called by-products became the principal object, and the charcoal the real by-product.

In the palmy days, before the repeal of the tax on grain alcohol used industrially, and before competition had lowered the price of the acetate, the by-products would pay for the wood from which they came, its carbonization and their recovery, leaving the charcoal literally as a by-product.

In order to turn this charcoal into money, some market for it must be had, and the easiest market was to build a furnace and run it virtually as an adjunct to the chemical plant. In this way many plants were run by men who had an exceedingly limited knowledge of the iron business and less of the quality of the iron they produced, and as, in their efforts to learn, they had to draw their information principally from the coke trade, the shrine at which they worshiped was high production.

The larger units led, naturally, to the introduction of economies which were not worth while in the similar plants of the East and South, notably the hot blast, from the use of which the coke trade found such great benefits in increasing production and decreasing fuel economy. It was natural that the charcoal producers should assume that the same conditions would hold with them to the same extent.

The iron was sold for what it would bring, and as the fuel cost was relatively low it could naturally be sold at exceedingly

FIG. 2.—TYPICAL SPOTTED IRON.

low prices compared with Southern and Eastern charcoal iron, where the wood by-product industry had never taken root successfully, in conjunction with the iron business.

Commercial pressure during successive depressions in the iron business took advantage of these conditions and of the

the feldspar $2(K Al_2 Si_3 O_8)$ thus introducing two extra atoms of Al, which, of course, would form Al_2O_3, if really presen' in practice.

If, however, the ordinary potassium-feldspar and the bauxite only are to be used, it seems that a reduction of the ore can only be effected through the carbon, which the author states "could" be introduced. In this case the spar and the bauxite are only slag-forming ballasts, and this would, of course, account for the unsatisfactory result obtained when the writer attempted to reduce the wolfram ore. The addition of metallic aluminium is not mentioned in the article.

It was fully evident that the reaction did not proceed of its own account after it had been heated to the ignition point by means of the electric arc, as would have been the case if free aluminium had been present.

The writer wishes to repeat, however, that there is plenty of room for explanations, which he hopes will be forthcoming, and that a single trial like the one described should not be considered conclusive; in the interest of general knowledge, however, the matter ought to be cleared up.

Luton, Beds, England.   JOH. HÄRDEN.

* * *

To the Editor of the Metallurgical & Chemical Engineering:

Sir: The time in which to reply to Professor Richards' recent and more courteous letter is too short to go into the matter as fully as I would like.

The object of the experiment of the number 4 graphite crucible was not, as Professor Richards says, to prove the reducing action of the flux so much as to prove the exothermic nature of the reaction. That carbon plays an important part in the reduction has not been and is not denied, but on the contrary it is considered an essential element. That packing of the graphite crucible in coal will produce a reducing atmosphere should be evident to any metallurgist without having it pointed out to him. However, the reducing atmosphere will not reduce ore and limestone under these conditions without the flux. Neither is it possible to melt steel scrap in the same reducing atmosphere. In fact, none of the ingredients of the charge taken by itself can be so melted. Yet the addition of the feldspar, bauxite and limestone to the ore will reduce the ore and produce a liquid steel which will pour as readily as water if it is not left in the stove too long after the reduction. If the metal is not poured promptly it will freeze in the bottom of the crucible. This same experiment has been made many times and has also been made with 50 per cent ferrotungsten.

I would suggest that Professor Richards make these experiments to satisfy himself. The actual demonstration is much more convincing than any amount of argument no matter how erudite. Whether the flux actually reduces the ore or whether it takes it up in a solution of vitreous slag so that the carbon, silicon or aluminium can act differently than they do in the usual processes, I will not undertake to say, but it undoubtedly does produce a reducing condition that is different and it undoubtedly is accompanied by a rise of temperature.

There seems to be considerable misapprehension as to the amount of flux required to produce the desired results. The amount of feldspar used is generally about one, and bauxite ½ per cent of the weight of the ore. There must be a sufficient amount of carbon present to accomplish the reduction, as the amount of reduction accomplished by the flux is probably small. The chemical explanation made in the article was intended to apply only to that portion of the reduction not accomplished by the carbon.

In regard to the quantity of flux to be used, the figures given are for the practical operation on a large scale. For laboratory experiments, especially with the No. 4 graphite crucible, the quantity required is from ten to fifteen times that given.

It is immaterial to me what the product of the stack furnace is called so long as Prof. Richards and I understand each other when its name is used. I had selected the word "sponge," but changed it to "matte," as my idea of a sponge is a refined metal in a state of loose physical structure, whereas matte is a partially refined metal, a term applied, it is true, at present almost exclusively to copper, but I see no reason why it should not be broadened. The product of this stack furnace is undoubtedly a partially refined product, as it carries the metal and all slag, including any sulphur, copper, or other impurity that may get into the furnace and that is not taken out by the blast.

Experimenters must not expect the exothermic reaction to be as violent as that of the "thermit process." When the temperature of the charge reaches the critical stage the reaction will increase the temperature above that of the surrounding fire or furnace, but upon withdrawal of the support of this outside source of heat so that the temperature falls by radiation or otherwise the reaction will cease.

I have not yet had time to go fully into the rather long letter of Mr. Joh. Harden, but it seems that the amount of feldspar and bauxite used was nearly a hundred times too much.

Pittsburgh, Pa.   WALTER O. AMSLER.

Proposed Code of Ethics of the American Institute of Chemical Engineers.

To the Editor of Metallurgical & Chemical Engineering:

Sir: I enclose an "Open Letter" to those who would impose a "Code of Ethics" on the American Institute of Chemical Engineers. Since the question at issue is of general interest, you may find it expedient to publish these views.

Dear Sirs: The fact that other engineering societies have adopted a "Code of Ethics" is not a satisfactory reason why the Institute of Chemical Engineers should adopt one. They may have made a bad mistake in adopting a code, and it would then be no credit to us to follow their example. Let us make our own mistakes, if we are going to make any, and not simply repeat the mistakes of others.

The Institute of Chemical Engineers was intended to be select, to contain only men of prominence and accomplishment in their profession. Its foundation was partly a protest against the indiscriminate character of the membership of the American Chemical Society, and because membership in that society conferred no distinction. Such being the high character of the membership of the Institute, it is unfitting and ill-advised to formulate "rules of conduct" for them, as if they were tyros in the art of being "an honest man and a gentleman."

The adoption of such a code would distinctly lower the dignity and distinction of membership in the Institute. It is, by assumption, unnecessary, because we elect as members only men who by action and achievement have shown themselves to be distinguished gentlemen. To prescribe to such, for example, that they shall "be guided by the highest principles of honor," is as unnecessary as it is silly and ridiculous; indeed, it is a gratuitous insult to every member of the Institute.

I do not hesitate to say, that if any member of the Institute has lost self-respect to such extent that he feels that he, himself, needs such a prescription as that just quoted, to keep him in the path of honor and rectitude, then he should be thoughtful enough to resign from the Institute before he brings discredit upon it. The Institute is not a reformatory.

Neither do I hesitate to say that any member who recognizes that he himself does not need such a prescription, but still would impose it on the Institute "for the benefit of his weaker brothers," is an unmitigated cad, and unfit to direct or influence the proceedings of the Institute.

I sincerely hope that the whole proposition will be voted "down and out" for good; every member who votes for it stultifies himself.

JOS. W. RICHARDS.

Lehigh University,
South Bethlehem, Pa.

The Effect of High Carbon on the Quality of Charcoal Iron

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low prices compared with Southern and Eastern charcoal iron, where the wood by-product industry had never taken root successfully, in conjunction with the iron business.

Commercial pressure during successive depressions in the iron business took advantage of these conditions and of the

actual decline in the quality of Lake Superior charcoal iron and forced its price down to a figure ridiculously low, compared with that of the Southern and Eastern irons.

In the summer of 1910 when the Lake Superior Iron & Chemical Company of New York was organized and took over six plants in the Lake Superior region, these conditions had prevailed so long that while the price of warm-blast Southern and Eastern irons ranged from $23 to $33 a ton at the furnace, with a ready sale for all that could be made, Lake Superior charcoal irons of far superior analysis, were a drug on the market at from $14 to $16 per ton.

Mr. Wm. Wilkins, the General Superintendent of the Iron Department of the above-named company, set himself the problem of finding the reason for this discrepancy in price, and of removing the cause if it was in the actual value of the iron. An investigation to find the conditions affecting quality was, therefore, undertaken at the Ashland plant, of which I was at that time appointed manager.

An investigation along the lines of consumption showed that different irons have different characters totally independent of their analyses. I do not for a moment intend to imply that the accepted opinions concerning the control of carbon condition by silicon, fluidity by phosphorus and chilling qualities by manganese are not in a general way correct. I do intend, however, to declare that the presence or absence of these elements *alone* will not account for all, scarcely for a half of the facts which have long been known, not to us, but to those who used high-grade irons for special purposes.

Investigation showed that there were foundries using chemistry not only for silicons and sulphurs, but also for carbon determinations and advanced work of that kind. We found that such foundries had proved by the most irrefutable tests that they could take a certain iron of a given analysis and produce certain results with it in chill, depth and uniform interlacing of chill with gray, hardness and toughness of chill combined, with corresponding resistance to abrasion, freedom from pits and from local failures of various kinds. With another iron of the same analysis they could not produce these results at all.

This was true not only of charcoal iron as compared with

FIG. 3.—WHITE PORTION OF FIG. 2.—70 DIAMETERS.

coke, but of one charcoal iron and another. We found that some carwheel manufacturers knew how to produce and did produce regularly, when they could sell them, wheels that would give service of many thousand miles in excess of that given by other wheels of their own make, made to be sold to people who insisted on having low price rather than quality. We were shown pieces of castings made with these different mixtures which contained ocular evidence sufficient to convince the most obstinate that there were physical variations not dependent on similarity of analyses in any recognized element.

As a result of these conditions there have grown up branches of the foundry trade forming a relatively small fraction of the whole, but of enormous commercial importance nevertheless, whose whole product is based on their being able to secure and to use irons which give them qualities beyond those obtainable from the ordinary coke foundry irons. These are particularly

FIG. 4.—WHITE PORTION OF FIG. 2.—38 DIAMETERS.

the manufacturers of chilled rolls and of chilled car wheels, though there is a growing demand for irons of high strength and close grain, without great chilling qualities, for many purposes, notably gas engine cylinders and the like.

The production of chilled car wheels in this country is enormous. The steel wheel has by no means filled the promise implied in the name of "steel." The first cost is very high and the durability is not great, even with the four expensive turnings which it receives during the course of its life. There is no difficulty whatever in demonstrating that more miles of wheel service under a given load may be obtained for a dollar with chilled cast iron wheels made of suitable irons properly mixed than can be obtained from a steel wheel, and in fact probably 90 per cent of the freight traffic of the country is carried on chilled car wheels to-day and will continue to be for many years to come. This branch of the business alone is of such vast commercial importance as to justify industrially and financially the great expense which has been incurred by the present investigation.

When the technical investigation was started I had no idea but that within a year or so we would have solved the problems presented to us, of which we had no detailed knowledge at that time.

This investigation has now been in progress for two years. In that time we have proven to be true many things which we did not believe, and have proven to be untrue many things of which we were firmly convinced, but we do not yet consider that we are within measurable distance of the final solution of the great problem—why one iron should be so different from another of the same analysis.

But experiments on the furnaces themselves, covering the widest possible range at all consistent with commercial operation, have indicated to us methods whereby the quality of the iron may be vastly improved from the state of things described in the introduction.

Some of our investigations on the iron itself have yielded partial results, and careful study of the relation between

furnace operation and quality of iron has enabled us to determine furnace lines and some of the operating conditions to give the desired results.

Practically all the plants have been rebuilt to embody the results of the investigation to date.

The investigation is still going on, and in its course we have come upon what seems to me the explanation of a phenomenon which has puzzled many—iron with a white or close spot in the center.

The difficulty of the investigation is one that is hard to overestimate, and even more difficult to explain to the satisfaction
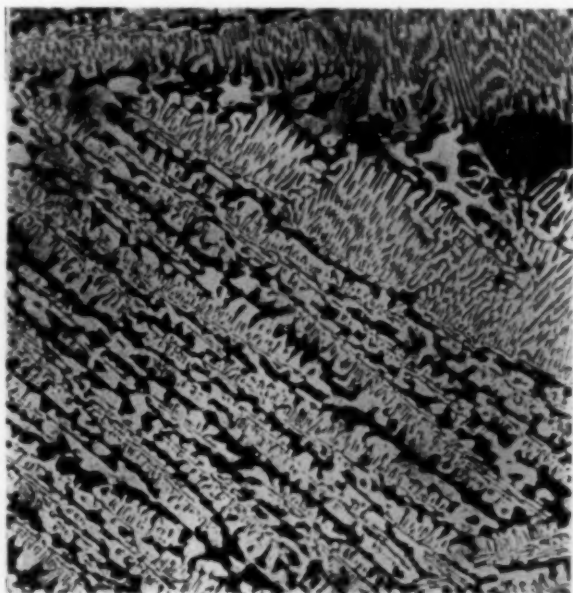

FIG. 5.—WHITE PORTION OF FIG. 2.—100 DIAMETERS.

of those familiar only with the coke iron trade.

I had been in the latter trade practically all my life and there was no one more deeply immersed in its traditions than myself.

I had taken some part in the development of the now accepted belief that soft steel, hard steel, white iron and foundry iron were members of a single series of iron-carbon alloys of increasing carbon contents, that silicon controlled the condition of the carbon, and that the chemical analysis of pig iron for the ordinary elements of silicon, sulphur, phosphorus and manganese, gave the final decisive word as to the character of the iron.

The logical ultimate deduction from this theory was that given the analysis, the character of the iron was established and virtually no attention need be paid to the fuel used in its production or any other consideration affecting its origin.

It is a matter of common knowledge that the only essential difference in the conditions when manufacturing iron with charcoal instead of coke consists in the fact that the charcoal is so free from sulphur that much less calcarious, and, therefore more fusible, slags can be used without danger of introducing sulphur into the iron. Any coke furnaceman, knowing this to be the sole essential difference between the two kinds of iron, and convinced, as most of them are, of the close correspondence between analysis and character, may well find it impossible to believe that such difference can exist, not only in strength but in appearance and structure between irons of similar analysis as we actually find in daily practice. That such a widely variant series of products can exist outside the knowledge of coke furnacemen is explained by the fact that we could run charcoal furnaces with slags similar to theirs and produce a line of products approximately similar to theirs in all respects, but by lowering the lime content of the slag we can bring into effect a vast series of varying conditions, which are masked, if not altogether obliterated, by basic slags

and the high temperatures necessary to fuse them. These conditions are impossible for coke iron, because the resultant rise in its sulphur contents would ruin it. I am moved to lay stress on this point of variations in quality not dependent on variations in analysis by the clear recollection that my own point of view when I first entered the charcoal iron field was that above outlined and probably is that of most furnacemen to-day.

It is true that I had noted with much interest certain variations in coke iron of the same analysis dependent on varying furnace conditions, and I had very definite ideas as to the type of fracture that was good and what was bad, as affected by these conditions.

These views, however, were distinctly subordinate to the broad view of analysis control of iron, of which I was a strong advocate.

When we were confronted with the overwhelming commercial fact that the Southern and Eastern irons sold for from 50 to 100 per cent more than we could obtain for our product, the natural and obvious thing to do was to claim ignorance and prejudice on the part of the foundrymen, and poor salesmanship on the part of the agents, because any tyro could compare the analyses of our iron with that of the Southern and Eastern irons and see that ours were the better.

Gradually, however, the indefatigable efforts of Mr. Wilkins brought us into contact with foundrymen who obviously knew their business at least as thoroughly in both practice and theory

FIG. 6.—LOW 4 SPOTTED IRON. VERY HIGH CLEAVAGE.

as we knew ours, and they gradually convinced us by the hard logic of irrefutable physical facts that the difference in price corresponded to a difference in quality and in ignorance, as we had supposed, but that we, and not they, were the possessors of the surplus stock of ignorance.

Experience with these Lake Superior charcoal irons taken in

conjunction with frequent analyses had led to the adoption of a grading card, which is given herewith:

Grade	Silicon Average	Chill Against Plate.	Manganese Carwheel Grade.	Manganese Malleable Grade.
AA Scotch	3.00% and over			
A Scotch	2.75			
B Scotch	2.50			
C Scotch	2.25			
No. 1 Soft	2.00		0.70% or over	Under 0.70%
No. 1 Special	1.75		0.70 or over	Under 0.70
No. 1 Foundry	1.50		0.70 or over	Under 0.70
No. 2 Low	1.25		0.70 or over	Under 0.70
No. 2 High	1.00	No chill	0.70 or over	Under 0.70
No. 3 Low	0.80	Feather	0.60 or over	Under 0.60
No. 3 Med.	0.65	½" to ⅜"	0.55 or over	Under 0.55
No. 3 High	0.55	⅜" to ¾"	0.50 or over	Under 0.50
No. 4 Low	0.45	¾" to 1¼"	0.45 or over	Under 0.45
No. 4 High	0.35	1¼" to 2"	0.40 or over	Under 0.40
No. 5 Low	0.30	Near white	0.35 or over	Under 0.35
No. 5 High	0.20	White, spot of graphite	0.30 or over	Under 0.30
No. 6 White	0.10	Clear white		
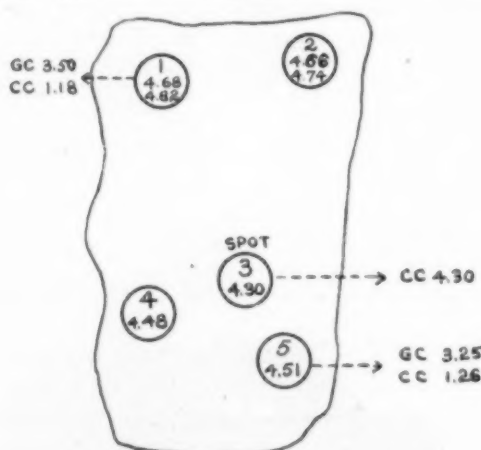
FIG. 7.—SHOWING POINTS OF ANALYSES.

Fig. 7.
ANALYSIS.

No.	Si. Per Cent.	Mn. Per Cent.	P. Per Cent.	S. Per Cent.	T.C. Per Cent.	G.C. Per Cent.	C.C. Per Cent.
1	0.32	0.32	0.118	0.022	4.68	3.50	1.18
					4.82		
2					4.66		
					4.74		
3					4.30		4.30
4					4.48		
5					4.51	3.25	1.26

It will be noticed that there is an assigned depth of chill for each analysis. To gauge the chilling qualities of an iron it is the custom to have a heavy block of cast iron planed on one side, which forms a portion of one side of the pig mold for one pig in every third bed. The chill on this chill block is the one referred to in the grading card given above.

The grading card was based on the three principal lines of consumption of these irons, as follows:

First. Straight foundry work, especially that of the better class where strength and density of grain were required, but not chilling qualities.

Second. The production of chilled casting, principally car-wheels and chilled rolls where manganese was supposed to be beneficial.

Third. The production of malleable cast iron, in which low manganese is generally specified.

It will be noticed that the silicon limits from one grade to another are very narrow and that the grades run much higher than No. 1. This is probably, to some extent, because the small quantity of sulphur present does not neutralize much of the effect of the silicon, so that the latter reaches the limit of its effect much earlier than in irons with higher sulphur, so conse-

quently No. 1 soft charcoal, with 2 per cent silicon, corresponds in some of its qualities to No. 1 soft coke iron, with 3.25 per cent silicon.
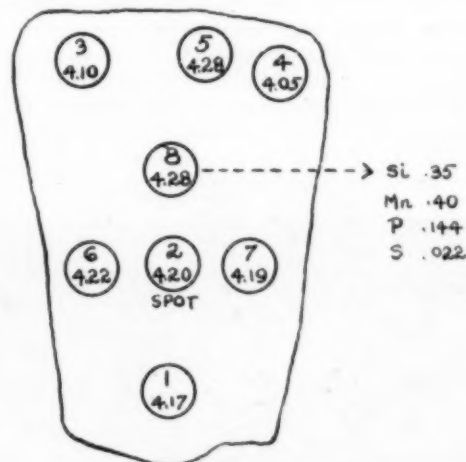

FIG. 8.—SHOWING POINTS OF ANALYSES.

Fig. 8.
ANALYSIS.

No.		T.C. Per Cent.	Si. Per Cent.	Mn. Per Cent.	P. Per Cent.	S. Per Cent.
1		4.17				
2	(Spot)	4.20				
3		4.10				
4		4.05				
5		4.28				
6		4.22				
7		4.19				
8		4.28	0.35	0.40	0.144	0.022

For the foundry trade silicon is needed for scrap-carrying purposes and the like, as with coke irons, and irons with more silicon than No. 1 soft are graded as Scotch irons.

Because of the rapid variation in grade, with small variation in silicon, the practice was early established of taking a sample for silicon analysis from every third bed and grading the iron by the results of these silicon determinations. Two manganese determinations were also made on each cast. This grading card was established several years ago, and, while it has recently been amplified, the silicon limits of the grades are practically unchanged.

When we began our investigation one of the great difficulties with which we had to contend was to find out what was good iron and what was bad. Was a strong iron necessarily a good iron, or a weak iron necessarily a bad one? It will seem inconceivable, but it took a year and one-half before we found anyone to give us a definite answer to this question. It was finally answered by the superintendent of the carwheel foundry of a large railroad system, who, by his practical knowledge of the business, and by physical tests of the irons he purchased, combined with judicious mixing and excellent foundry practice, produced wheels that stood an average of ninety-five thousand miles in service, as against an average of from thirty to forty-five thousand miles for the wheels of the ordinarily commercial wheel foundries.

This gentleman assured us that for his purpose a good iron was a strong one, and a strong one a good one. The standard of strength with him was a 2-in. square bar, broken transversely on centers 12 in. apart. If the strength for a given grade was up to certain limits and the chill of a certain depth, the iron was good. If not, the iron was undesirable for his purposes and was rejected.

This condition of complete ignorance as to what to investigate caused the investigation to take shape very slowly. We

started at once with pyrometric observation of the temperature of the running iron and cinder, and bought a small transverse testing machine, capable of breaking a 1¼-in. round bar on 12-in. centers, the standard recommended by the American Foundrymen's Association. We cast four bars on end in green sand molds with iron dipped directly from the runner, at each cast, and broke these on the testing machine. We believed, however, that we should have a record of the stress-strain diagram of the test bars and we accordingly bought, a little later, an autographic machine, designed and made by Tinius Olsen & Co., of Philadelphia, for this purpose. This machine draws a line on a 5-in. square chart, the abscissae of the line showing the stress applied, and the ordinates the corresponding deflection, right up to the point of rupture. After certain minor changes were made this machine was easy to manipulate and the quality of the iron was soon found to have a decided bearing on the character of the curves produced.

There were two well-established traditions in the business when the investigation was begun. One was that an iron with a white chilled spot in the center of the pig, which is some-

FIG. 9.—CORNER OF PIG SHOWN IN FIG. 6. SHOWING LAMINATION. UNETCHED. 70 DIAMETERS.

times produced, was weak and utterly worthless for the manufacture of chilled car wheels, or in any other purpose requiring a strong, tough chill. This is known as "spotted iron."

Second, that an iron was made under certain conditions in which the grain was exceedingly close, verging slowly into a chill of greater intensity than the silicon contents of the iron would explain, and that this was a very strong, tough iron, particularly suited for cylinder castings on account of its high strength and exceedingly close grain, taking a high finish. In consequence it was given an individual name, "special cylinder iron," and saved for certain customers to whom it was particularly valuable, though it is a lamentable fact they formerly got it without paying anything like an adequate price for it. This iron is produced as the result of certain unusual furnace conditions, and may have any silicon contents from 0.5 per cent to 2 per cent.

The first positive results of the investigation were to prove that this special cylinder iron was far stronger than normal, and that, on the other hand, the spotted iron was far weaker, thereby confirming thoroughly the traditions of the practical men whom it had been the custom to deride.

At the expense of much time and money, Mr. Wilkins secured samples of the best brands of Southern and Eastern irons, from which remelts were made in order to determine their strength, also complete chemical analysis for comparison

FIG. 10.—CORNER OF PIG SHOWN IN FIG. 6. SHOWING LAMINATION. UNETCHED. 70 DIAMETERS.

with our own. Gradually it developed that we needed something more, and a microscopic outfit and polishing apparatus were added. Subsequently it became a conviction in the minds

FIG. 11.—CORNER OF PIG SHOWN IN FIG. 6. SHOWING LAMINATION. ETCHED. 70 DIAMETERS.

of all, particularly in that of Mr. Wilkins, that reliable carbon determinations were a necessity.

It is well known to all who have tried to get carbon determinations of pig iron that there is no greater bugbear in the laboratory, and the attempt to obtain accurate ones lasted for a

year before we had discovered all the conditions necessary to get reliable results. We soon found, however, that one carbon determination per day was not enough, and we then added an extra man in the laboratory and began to get total and graphitic carbons on every cast in addition to the six silicon and two manganese determinations for each cast. We added also a phosphorus and sulphur determination for each cast, and by means of the latter destroyed the beautiful delusion that good charcoal iron ordinarily contains about 0.01 per cent sulphur, since accurate determinations show nearly all of it to contain from 0.015 per cent to 0.020 per cent, even when made from the best of ores, and very much higher if there is more than a trace of sulphur in the ore.

More than a year ago we put in a crucible furnace for making crucible remelts of irons, to determine the effect of
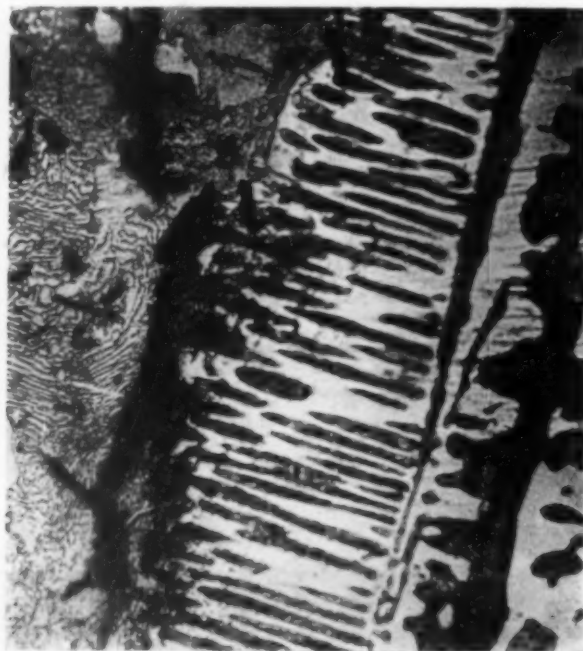

FIG. 12.—CORNER OF PIG SHOWN IN FIG. 6 SHOWING LAMINATION. ETCHED. 450 DIAMETERS.

remelting on our own iron and to obtain results comparative with those of others which are generally made on remelted iron. If the test is to represent the actual quality of the iron crucible remelts must be used to prevent oxidation, contamination with sulphur, and the like.

We at first made these remelts only on very unusual irons of our own or on irons from outside sources, and used the 1¼-in. round test bar, but later, finding what great dependence the foundrymen placed on the 2-in. square bar, broken transversely on 12-in. centers, we began making remelts of every cast of iron suitable for chilling purposes—that is, everything below the No. 1 grades, making both 2-in. and 1-in. square test bars.*

In order to utilize all this information, the iron is all piled by grades, but the portion of a given pile which comes from

*The transverse strength of a good 2" square test bar on twelve-inch centers will sometimes go as high as 30,000 pounds, and to break these and at the same time avoid the expense of buying a testing machine of this capacity, we rigged up a removable girder over our track scale to carry a screw and ratchet lever strong enough for the purpose. The screw carries at its lower end a knife-edge, which is guided by a square shank to prevent its turning. The test bar is placed on a pair of knife-edges, twelve inches apart, resting on transverse I beams inserted between the main I beam of the scale platform. Guide pins run through guides mounted on the girder which carries the screw, and through guide holes in the plate carrying the bottom knife-edges. These locate the bottom knife-edges accurately under the center of the top knife-edge in both directions. The stress is put on the bar by the hand lever, as shown, and the load on the bar weighed on the scale beam. With very little practice it is possible to get results accurate within one hundred pounds or less. As the apparatus serves the purpose of an expensive testing machine very satisfactorily for those who have a relatively small amount of such work to do, it is thought that its description may not be amiss.

a given cast is bulkheaded off from the portions on either side of it and marked with a tag, giving the date and hour of the cast and the silicon and manganese of that portion of the pile. The daily furnace reports carry the ordinary information contained in a daily report, and in addition, the carbon determinations, at least one slag analysis, the temperature of the running iron and cinder, the breaking strength of 1¼-in. round bars poured from the cast, and the breaking strength of the remelt bars on the chilling grades of iron. By means of this system we know the exact iron which goes out on each order, and when we get an order for exactly the same kind of iron, we can take our records and locate it with little or no difficulty. In this way we are able to direct the various grades and kinds of iron to the fields of consumption to which they are best adapted. This system involves extensive records and a considerable amount of clerical work, but gives results so satisfactory to consumers that we find it well worth while.

The opinion gradually took shape in my mind that the spotted iron, the normal iron and the special cylinder iron were the members of a continuous series of increasing quality, and that if we could find out the cause of the spotted iron and the proper method of prevention, we would have at least part of the problem solved. This view has gradually been confirmed by the progress of the investigation, and we have further found some of the factors which tend to increase the strength of the iron and move it from the normal to the special cylinder quality.

We do not feel that we have yet reached the complete solution of these matters in such a degree as would make

FIG. 13.—CORNER OF PIG SHOWN IN FIG. 2. NOTE RELATIVELY SLIGHT LAMINATION COMPARED WITH FIGS. 9-10. UNETCHED. 100 DIAMETERS.

their publication safe and desirable, but we think we have succeeded in finding the cause of the spotted iron and in connecting up its analysis and physical qualities and assigning to it its proper place on the iron-carbon diagram.

Fig. 2 is a photograph of a representative piece of spotted iron. It shows the white spot in the center with two rudimentary branches extending toward the upper corners of the pig. When I first gave thorough consideration to this kind of iron it seemed to me that the location of the white spot

indicated that it was a segregation product, and I had analyses made of the gray portion outside and of the white spot, with the result of finding that the total carbon was about ½ per cent higher in the former than in the latter, but no material variation in the other elements, certainly none in either the silicon or the manganese, which would account for the internal chill in spite of its being slowly cooled.

I was informed by experts in the metallurgy of iron that the ordinary explanation of this phenomenon was that the

FIG. 14.—HIGH NO. 3 IRON WITH TENDENCY TO SPOT.

ANALYSIS OF HIGH NO. 3 IRON SHOWN IN FIG. 14.

	Per Cent.
Si.	0.45
Mn.	0.38
P.	0.124
S.	0.019
T.C.	4.46

center of the pig was still liquid when the exterior had solidified, and that the expansion which accompanies the evolution of graphite was not permitted to take place on account of the contraction of the solid envelope on the liquid interior, but as iron of all grades cools under precisely these conditions and only a small percentage of it is spotted, this explanation could not be regarded as satisfactory.

Gradually investigation and observation developed the fact that the irons in the low and high No. 4 grades were most apt to be spotted, but that a tendency to spot was sometimes shown in softer grades, notably the No. 3 iron, even though the pig itself might not show any trace of spot. For instance, the test pins in these grades might have a very small spot, even when the pig had none at all.

We have repeatedly heard the term "high cleavage" used in connection with the Lake Superior charcoal irons by experienced users, and we had at one time considered that this was part of their unreasonable prejudice against this iron, but we gradually found that certain irons which had this tendency to spot showed a degree of lamination where they were chilled, or partly chilled, that was almost beyond belief. In the corners of some pigs there could be seen with the naked eye alternate layers, perfectly white and solid gray, the white leaves being no thicker than ordinary writing paper, the gray perhaps twice as thick. It was obvious that such iron must break along the faces of these leaves of white, and that the term "high cleavage" expressed its quality more accurately than any other equally simple term. Stereoscopic photographs (which, unfortunately, cannot be reproduced in the printed paper) will be shown to all interested, which illustrate the characteristics of the fracture of this iron more accurately than any amount of description.

Observation gradually brought out the fact that while the special cylinder irons showed a tendency to chill much more than their silicon contents would lead one to expect, these

irons with a tendency to spot, even though not actually spotted, showed a chill much lower than their analysis would warrant, and more than a year ago we began the practice of marking such iron with a distinctive mark and forbidding its shipment to manufacturers of chilled car wheels or any similar article, because we found the testing machine confirmed the ocular judgment that these irons were of the general nature of spotted iron, and therefore, very weak. We had photomicrographs made of the irons shown in Fig. 1, particularly the spotted portions which are reproduced in Figs. 3, 4 and 5. It is obvious that the masses of detached plates of which these areas are made up simply abut against one another and are not in any way interlaced, so that a very low intensity of stress will cause cleavage along the face of one or the other of them. We finally recognized the structure as shown by the photographs to be that of eutectic cast iron of 4.30 per cent carbon, as shown by Fig. 118, page 175, of Goerens' "Introduction to Metallurgy."

Simultaneously with the microscopic examination of a specimen of this iron we repeated our earlier determinations of the carbon in the light of the most recent developments in those determinations, with a view of corroborating our earlier results, and we obtained the results shown on the accompanying chart. It then became evident that our earlier opinion that this was a segregation product was correct and that the white chilled spot was the eutectic of 4.30 per cent carbon, which had gone to the same relative position in the pig as that in which we find the segregated portion of a steel ingot and for the same reason; that both had remained molten on account of their low freezing temperature after all the other portions of the mass were solidified.

From this point the investigation and this description of it naturally divides into two parts. First, what are the causes

FIG. 15.—CORNER OF PIG SHOWN IN FIG. 14. UNETCHED. 70 DIAMETERS.

of this action? Second, how far does the action extend and how serious are its effects in industrial work?

Without any desire, or ability, to make this a purely scientific matter, it was necessary to align the results of the investigation with the established iron-carbon diagram in order to check our results, and the portion of the article from this point to the end of the fifth paragraph on page 786 seems to us the explanation of the observed facts on this basis. From that point on the conclusions based upon those facts are given. My

rudimentary knowledge of the iron-carbon diagram prevents the former portion from being particularly technical, but it may be undesirably so, for those who desire conclusions only, and all such may omit the former portion without other loss than the danger of being misled by erroneous conclusions in the latter section. As these are based principally on observation and but little on deduction, this danger is not serious.

It so happened that our first investigation of carbon contents in various portions of the face of the pig was made not on the iron shown in Fig. 2, but on that shown in Fig. 6. These carbon determinations and their location are shown by Fig. 7. It will be observed that the carbons in the gray portion are all much higher than that in the spot, and being unfamiliar with the interpretation of the iron-carbon diagram we first assumed that it was only hyper-eutectic irons which could thus segregate and that the phenomenon was one confined to the right hand branch of the iron-carbon liquid diagram.

This error was fostered by the fact that we had a suspicion that the high carbon irons were the bad ones. We came gradually to realize, however, that this explanation was not valid and that segregation of eutectic could take place in hypo-eutectic irons as well as in hyper-eutectic, so that any interpretation of the facts based on the former assumption only was wrong.

It is obvious that irons on the right hand side of the eutectic point throw out only graphite in cooling down to the eutectic freezing point, so that the ground mass of the whole pig, exclusive of the small proportion of graphite so thrown out is eutectic at the time of final solidification. But the center is free of these particles of this graphite because it has remained liquid so much longer as to give them a chance to separate out by gravity into the portion above the spot. Therefore, when the iron cools down below the eutectic freezing point, the portion around the spot contains many particles of graphite which probably act as foci to cause other graphite to precipitate out of the mass from the solid condition. The

FIG. 16.—CORNER OF PIG SHOWN IN FIG. 14. ETCHED, 70 DIAMETERS.

center is without these foci, and is, moreover, under compression from the contraction of the previously solidified exterior, which prevents the expansion necessary for the evolution of graphite, therefore, no graphite forms.

The iron shown in Fig. 2 was subsequently analyzed for carbon at eight points, as shown in Fig. 8. It will be seen

that the spot contains the highest carbon, except the gray portion immediately above it, which is only slightly higher. The first-cooled portions of the pig, however, are all lower in carbon than the spot. In these portions solidification has obviously taken place, first, as austenite with a lower carbon content and correspondingly higher freezing-point than the

FIG. 17.—CORNER OF PIG SHOWN IN FIG. 14. ETCHED, 450 DIAMETERS.

eutectic. These portions had no deposition of foci of graphite while liquid to induce the precipitation of more graphite during cooling in the solid state, but had the ability to form a solid structure of austinite (undoubtedly immeshing pools of eutectic therein) which would solidify earlier and therefore be in better position to exert pressure during contraction on the central liquid portion than if all froze at the same temperature. In other words, the austenite is capable of making, and does make, a continuous structure with a freezing point higher than the eutectic, whereas the graphite in the hyper-eutectic irons cannot form any continuous structure and does not affect the freezing temperature of the principal portion of the exterior mass.

We have here also the obvious action that when there is carbon in excess of the eutectic ratio the excess falls out and the whole mass, except these isolated flakes of primary graphite, is composed of eutectic. In the hypo-eutectic irons, on the other hand, it is obvious that less eutectic can be formed according as the carbon content of the whole is further below the eutectic ratio.

In the hyper-eutectic irons the isolated particles of graphite can exercise but little influence on the formation of the plates of eutectic whose shape, size and utter lack of interlacing accounts for the poor physical qualities of this kind of iron. In the hypo-eutectic irons, on the other hand, a skeleton of austenite called by Professor Howe primaustenoid, forms first, and being relatively solid through being well below its freezing point at the time of the freezing of the eutectic, can prevent the formation of large plates of the latter, which, if formed, act like gigantic cleavage planes on the mass as a whole. The further the carbon content of the whole is below the eutectic ratio, the earlier must be the freezing of the austenite and the greater its quantity before the formation of the eutectic can begin. Therefore, the more powerful will it be in preventing the formation of the huge plates of eutectic when the eutectic freezing point is reached, while the quantity of the

latter which can form is diminished at a still more rapid rate.

If this explanation be correct it is obvious that the cleavage condition, visible to the naked eye, must be vastly more extensive in a hyper-eutectic spotted iron than in a hypo-eutectic one, and that it must extend to the very exterior of the pig in the former and be more and more restricted to the center as the carbon is lower in the latter. These conditions we find in fact to exist. The fracture of the iron at the exterior of the pig, shown in Fig. 2, is not particularly high cleavage, whereas the iron shown in Fig. 6 is of most peculiar appearance. There are close-grained spots scattered all over its face, not perfectly white, but visible upon close examination to the naked eye as plates of solid white alternating with layers of gray; in other words, the most accentuated condition of cleavage we could find. This cleavage condition is usually manifested particularly in the upper corners of the pig, and from one of these corners of this pig we took a specimen which was polished and photographed without etching, so as to show the lamination and orientation of the graphite. This is shown in Figs.

FIG. 18.—LOW NO. 2 IRON.

9 and 10. The same sample, etched and at the same magnification, is shown in Fig. 11 and under higher magnification in Fig. 12.

In order to prove if a contrast existed we took a similar corner of the pig shown in Fig. 2 and prepared a specimen in the same way. The result is shown in Fig. 13, unetched.

It will be seen at a glance that the laminated condition is much less and the graphite much less oriented in this specimen than in the other one. This being a hypo-eutectic iron, the portion which froze first was austenite, and there were only puddles of eutectic left to make the few long flakes of this material shown. The graphite is fine, scattered and nodular, an indication of its being secondary graphite, while some of the graphite in Figs. 9 and 10 is large and in relatively long flakes, an indication of its being primary.

Allusion has been made to irons which had a tendency to spot without being actually spotted. These irons usually occur in the No. 3 grades. In addition to these we have noticed irons in the No. 2 and even softer grades, with a close spot in the center, surrounded by more open-grained material.

After we had this clue it was relatively easy to find from the results of the test bars that those casts with this fracture were likely to be below the normal strength for their grades, and by examining the upper corner of the pig we were able, in some cases, to detect slight traces of cleavage. We accordingly prepared a specimen from the upper corner of a pig of high 3 and photographed it without etching.

The original pig is shown in Fig. 14, and the micro-photograph of the specimen in Fig. 15. The cleavage planes and the orientation of the rows of graphite show a structure obviously identical with that in Figs. 9 and 10, though slightly less pronounced. This also was a hyper-eutectic iron, as shown by its analysis. The same structure, etched, is shown in Fig. 16.

If the theory outlined above is correct it is obvious some of the graphite in the hyper-eutectic irons is primary, and if so, it will naturally occur in relatively large flakes quite thin in relation to their length and breadth. Moreover, the graphite, not having any continuity of structure, is obviously at the mercy of the eutectic crystals, and when the latter begin to form they can push the graphite flakes around so that while the long axes of the flakes may not be aligned, the flakes as a
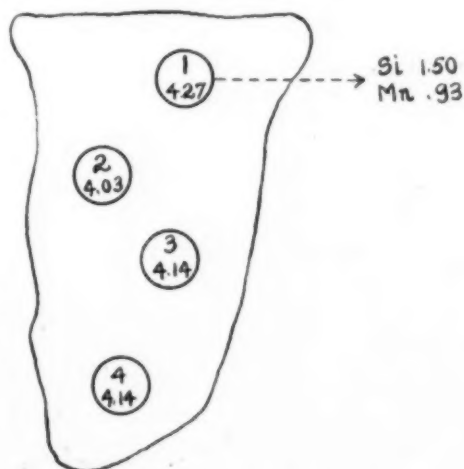
FIG. 18a.—SHOWING POINTS OF ANALYSIS.

ANALYSIS OF PIG LOW NO. 2 SHOWN IN FIG. 18A.

No.	T.C. Per Cent.	Si. Per Cent.	Mn. Per Cent.
1	4.27	1.50	0.93
2	4.03		
3	4.14		
4	4.14		

FIG. 19.—CORNER OF PIG SHOWN IN FIG. 18. NOTE ORIENTATION OF GRAPHITE. UNETCHED. 38 DIAMETERS.

body are arranged in windrows. This condition is plainly evident in Figs. 9, 10, 11, 12, 15 and 16. Fig. 17 is the same as Fig. 14 at a higher magnification, and shows the same condition within its limited field.

It will be noticed that the plates of eutectic shown in Figs. 15, 16 and 17 are considerably more broken up than the similar areas in Figs. 3 and 4. This I take to be the result of the greater silicon content of pig shown in Fig 14 than that shown in Fig. 2, and is reflected in the solid gray fracture of the

latter as compared with the partially white fracture of the former. The effect of silicon is obviously to break up these plates of eutectic into pearlite and cementite, and then, in some cases, to break the latter up into pearlite and graphite. If this be true, then we should have an orientation of the graphite even in irons so high in silicon as to have left scarcely any traces of the original eutectic.

In order to prove or disprove this hypothesis we took a pig of low No. 2, shown in Fig. 18, in the corners of which we found faint indications of cleavage and prepared a specimen

FIG. 20.—CORNER OF PIG SHOWN IN FIG. 18. ETCHED. 100 DIAMETERS

from its upper corner, which is shown in its unetched condition under low magnification in Fig. 19. The orientation of the graphite from the upper left to the lower right-hand corner is plainly visible. 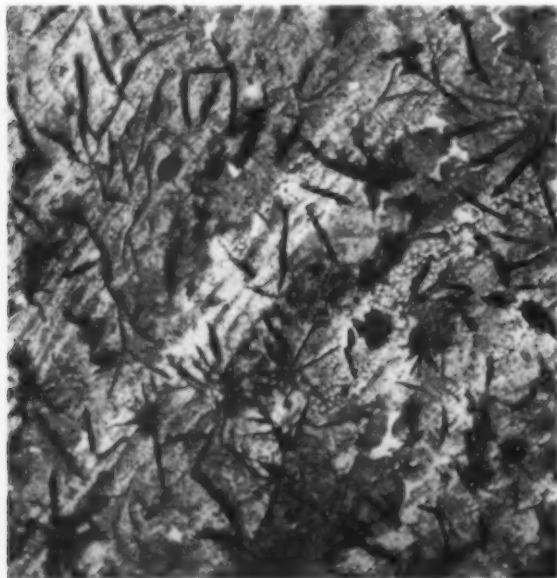The same specimen etched is shown under a higher magnification in Fig. 20. In this the long windrows of white dots represent all that is left of the cementite, which once composed part of the eutectic plates. The darker rows of graphite flakes are plainly observable between the windrows of white dots. The carbon determinations taken in the face of this pig are shown in Fig. 18.

We seem justified in believing that this was a hyper-eutectic iron in which the silicon had forced down the eutectic point to about 4 per cent instead of 4.30 per cent. The fact that the segregated spot is lower than the rest of the pig in carbon and the presence of the residual plates of eutectic in the corners, which we have seen are most likely in hyper-eutectic irons, is our justification for this belief.

In order to confirm the above theory more fully, we took one normal white iron containing 3.71 per cent carbon, made under ordinary working conditions for white iron, and a white iron made on a very cold furnace, containing only 3.3 per cent carbon, and prepared specimens from each. Photomicrographs of these are shown in Figs. 21 and 22. The former will be seen to have a well developed pine-tree structure at the point photographed, and at other points in the same sample this structure was even more markedly developed. In the low carbon iron it will be seen that there is no sign of the pine-tree structure, and careful search of the whole field of the specimen reveals scarcely any of it, thus proving that when the iron is far enough below the eutectic ratio this structure cannot form to any appreciable extent.

The fact that eutectic can form in iron practically free from silicon, as low in carbon as 3.71 per cent and practically without segregation (the carbon in the center being 3.72 per cent as against 3.71 per cent at the side), may be thought con-

tradictory to the theory here advanced. Examination of this iron under the microscope seems to indicate that there probably was the early formation of austenite which had its effect in orienting the flat crystals of eutectic as they formed, so that they are much more interlaced than any higher carbon white areas. It would seem as though the original austenitic structure had been overwhelmed by the crystals of eutectic freezing from the pools of that material enclosed by the austenite network.

While these investigations were in progress Mr. R. W. Durrett, manager of the Newberry plant of this company, determined some of the conditions controlling the carbon contents of pig iron and was enabled to produce irons of very low carbon, in some cases as low as 3.3 per cent. We happen to have here a specimen of this iron, with the analysis shown. The closest examination by eye failed to show any traces of cleavage and there was not the slightest indication of spotting. Specimens of the iron were prepared for the microscope and photographs of the results under different manifications are shown in Figs. 23, 24 and 25. The irregular polygons of primaustenoid are quite plainly visible, but there is not the slightest sign of any residual of the eutectic. This iron is evidently so far below the eutectic ratio that the heavy network of primaustenoid completely overwhelms the attempt of the eutectic to crystallize into flat plates. This is the easier, as but very little of the eutectic can form with this low carbon content. The structure of primaustenoid is one which we have learned to associate with high strength, and there is no doubt that a test of this iron would show a high result, though we have not such a test available.

We have endeavored to obtain specimens of coke iron containing such white spots in the center, but so far without success. My recollection is quite distinct, however, that these irons are not infrequent in basic practice. We shall take the first opportunity to determine whether the same conditions hold in those irons as those here shown.

Allusion has been made to the fact that irons, either spotted or with a tendency to spot, are commonly deficient in chilling
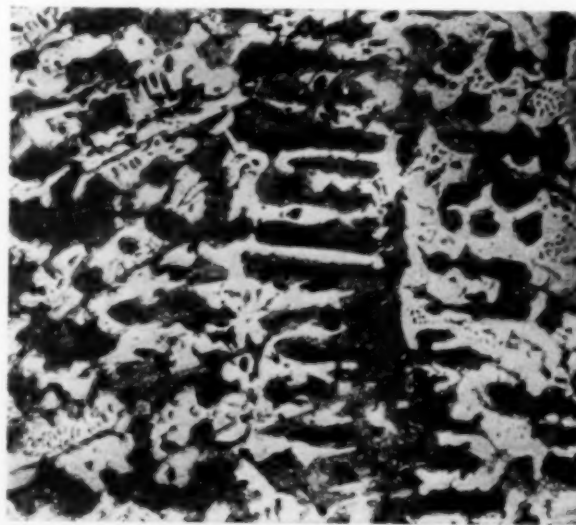
FIG. 21.—HINKLE REGULAR 6 WHITE. ETCHED 5″ 2.5% HNO₃ EDGE OF PIG. WHITE IRON 3.91 CARBON. ETCHED. 100 DIAMETERS.

qualities, as well as strength, and that such irons are specially marked when made and never shipped to consumers who require those qualities.

The reason why irons with a tendency to spot are deficient in chilling qualities is a point which we have not yet worked out. We have established beyond the possibility of a doubt that it is not dependent solely on the carbon in iron. We have seen two irons of the low No. 4 grade, of which the carbons

were identical within the limits of chemical error (4.06 per cent and 4.07 per cent), and yet the chill on one was about ¼ in. deep, on the other about ¾ in. deep.

It is entirely possible that part of the cause may be the temperature at which the iron is cast. The tendency is, in our opinion, for the chill to be reduced by casting at a higher temperature. It is fairly well established that high hearth temperature (other things being equal) tends to promote high carbon. It may, therefore, be that deficient chill and high carbon are the joint results of the same cause, high hearth temperature, rather than having any relation of cause and effect with one another. It must be borne in mind, however, that as stated in the beginning, there is some other factor, perhaps more than one, affecting the quality of the iron in addition to analysis in the ordinary elements, even including the results herein contained concerning carbon. We have had this fact forced on our attention in so many ways that we feel called on to reiterate it at every opportunity, but I do not wish to go into the details of that subject now.

It is not at first sight obvious why these spotted irons should be confined, roughly, within silicon limits of one-quarter and three-quarters of 1 per cent. The reason is probably two-fold.

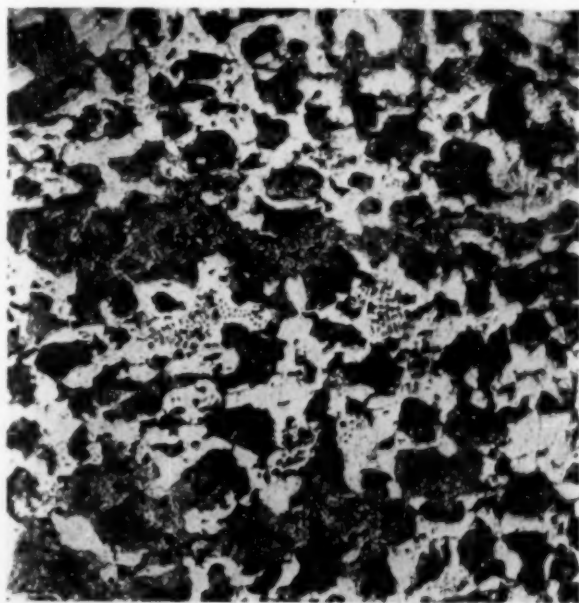FIG. 22.—WHITE IRON OF 3.30 CARBON. ETCHED. 100 DIAMETERS.

Very little is known about the conditions which control the amount of carbon in pig iron, but two of the facts well understood are that a cold hearth producing white iron gives a low carbon. On the other hand, a hot furnace giving an iron high in silicon also produces a low carbon because of the tendency which carbon and silicon mutually exert toward excluding one another from iron within certain limits. The common illustration of this is "silvery" iron in which the silicon is so high as to keep the amount of carbon absorbed well below the ordinary range, leaving the white of the iron to show through more than the mass of graphite in normal irons will permit. Between these two extremes of low silicon and high silicon the carbon contents of the iron rise to a maximum presumably around ½ per cent in silicon, the hearth not being cold enough when running on these irons to prevent the absorption of carbon on one hand and the silicon not high enough to crowd it out, on the other.

These irons, therefore, under ordinary conditions, are the most likely of any to contain carbon well above the eutectic point, and so to lend themselves to segregation and the consequent formation of the austenite-pearlite eutectic. Moreover, these irons contain enough silicon to throw some of the carbon

into the graphitic form as they cool below the eutectic temperature, but they do not contain enough to throw out graphite from the segregated spot against the compression of the solid exterior.

When the silicon is lower than this its effect is insufficient to throw any marked amount of carbon into the form of graphite, below the eutectic freezing point, even though the

FIG. 23.—NEWBERRY HIGH 3. UPPER CORNER OF PIG. 38 DIAMETERS.

iron throws out a little primary graphite while cooling down to that point. Irons higher in silicon, on the other hand, exert so great a graphite-forming tendency as to cause its formation from the solid in the segregated spot, but on account of the pressure the graphite tends to take the nodular form, occupy-
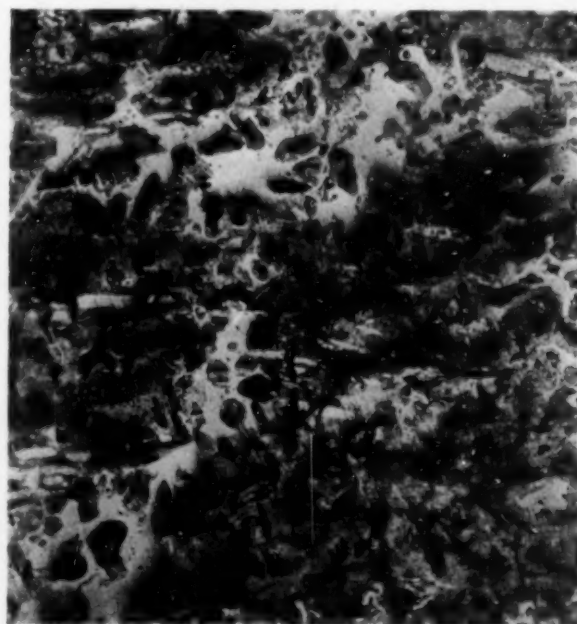
FIG. 24.—NEWBERRY LOW CARBON IRON. ETCHED. 100 DIAMETERS.

ing the least possible room rather than to take its customary flake form. This causes the fine-grained gray structure in the segregated spot.

In regard to these comparatively soft irons with a close spot in the center, it is necessary to exercise great caution in passing judgment. The primitive eutectic plates are so completely broken up that graphite cuts through them as well as parallels

them. Moreover, during the process of breaking down, these flat plates form ribs at right angles to the principal axis of the crystal, and these ribs give an interlacing effect which is entirely wanting in the partially white spotted irons. There is much reason, both practical and theoretical, to believe that some very excellent irons may contain a close spot in the center.

CONCLUSION.

1. Spotted irons are products of carbon segregation.

2. This segregation may take place in irons containing either more or less carbon than the eutectic ratio.

3. The segregation is less marked and less likely to have ill effects the further the carbon is below the eutectic ratio.

4. When the fracture of an iron shows high cleavage at the edge it is almost sure to be up to, or above, the eutectic ratio, and is virtually certain to be a weak iron.

5. Close spots not associated with cleavage may occur in irons of good quality, especially where the silicon is comparatively high.

6. While we have discovered the cause of spotted irons and irons of high cleavage and the reason for their corresponding weakness, it is my firm conviction that there is another condition, element, substance, or what you will, that makes for
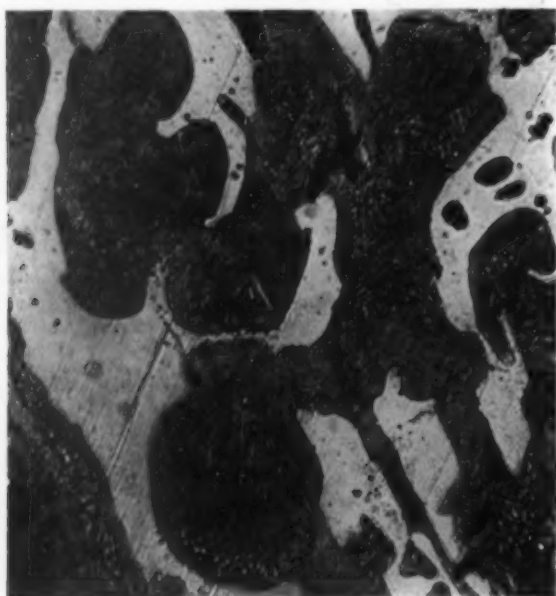

FIG. 25.—NEWBERRY LOW CARBON IRON. ETCHED. 450 DIAMETERS.

ANALYSIS OF NEWBERRY LOW-CARBON IRON, FIG. 25.

	Per Cent.
Si.	0.55
Mn.	0.18
P.	0.260
S.	0.042
T.C.	3.50

strength and for high chill with a given silicon content in just the same way that high carbon is here shown to make for weakness and low chill with a given silicon content. What this unknown condition may be I do not yet know, though I have some unconfirmed opinions on the subject. But there are many things which make us believe that with this other condition properly fulfilled a relatively high carbon iron may be stronger and better than an iron of much lower carbon, with this condition absent.

In illustration of this it may be well to call attention to cold blast irons which command a price much higher than that of any other kind of pig iron, and which our investigations, nevertheless, have shown to be quite high in total carbon, frequently well over 4 per cent.

We are continuing the investigation with all the means at our command to determine what the remaining unknown condition may be, but this paper is designated as a "preliminary paper" to denote our firm conviction that there is far more to be learned on this subject than is contained in this paper. We think we have proven that high carbon by itself makes an iron weak and poor, but low or moderate carbon by itself is not enough. It is my hope that we shall eventually discover what causes good iron to be good, as well as what causes poor iron to be poor, and since we have been able, even with our present relatively slight degree of enlightenment, to improve the quality of our iron and to apply different grades to the service for which they were best adapted, so we have confidence that we shall eventually succeed in producing the grades and qualities we desire, approximately at will.

Ashland, Wis.

Extraction and Purification of Platinum.*

By HARRY F. KELLER, PH.D.

Since the platinum of commerce is exclusively derived from alluvial deposits, the methods employed for its recovery are essentially similar to those employed in gold placers; indeed, if we except the Uralian districts, it may be said that platinum is generally obtained as a by-product in gold washing.

The Russian platinum-bearing gravels, which are covered with barren material, from a few feet to 50 ft. in depth, are worked partly by open mining, but usually by sinking shallow shafts and drifting along the pay streak. The latter, as a rule, is only a few feet in thickness, and the gravels are said to run from 0.05 to 1 ounce per cubic yard.

The washing plants are mostly of a peculiar, rather primitive construction, though quite recently modern methods and apparatus have been successfully introduced on some of the properties.

(For descriptions and recent improvements in the recovery of platinum, with or without gold, see Mineral Resources, 1905-1906.)

The metal obtained by washing and various concentrating processes, and freed from gold, constitutes the crude platinum, or platinum ore, of commerce. This contains various metals that render the platinum unworkable, and the ore has to undergo a refining process to convert it into the commercial form.

Many attempts to render platinum malleable and ductile were made during the latter part of the eighteenth century, and while a few men, like Achard, the Count von Sickingen, and the skilful metal workers Chabanneau and Jeanetty, of Paris, succeeded in doing it on a small scale, it was not until the early years of the nineteenth century that the platinum industry was really founded, and the creators of this industry were Englishmen.

About the year 1800 Charles Knight devised a process which, while still imperfect, embodied the principal features of the method by which all commercial platinum was obtained for more than 50 years. It consisted in dissolving the crude metal in aqua regia, precipitating the solution of the chloride with sal ammoniac, then packing the dried precipitate into conical molds of fire clay, and strongly heating it in the mold. It is said that the metal was thus obtained as a coherent mass which could be hammered and worked into various forms.

The product, however, still lacked solidity and homogeneity, and it was only by certain important modifications and improvements that it became a commercial success. The improved process is usually credited to the chemist Wollaston, but according to Roscoe the main features were invented by a relative of a member of the firm of Johnson & Matthey.

*A part of a Franklin Institute paper entitled "Platinum, the most precious of metals." In the above we only give the part dealing with the extraction and purification of platinum. The full paper, which also contains notes on platinum minerals, properties and uses of platinum and production and value of platinum, may be found in the November issue of the *Journal of the Franklin Institute.*

However that may be, it is certain that the improved process was first described by Wollaston in the Bakerian lecture for 1828, and Faraday, who was undoubtedly well informed on the subject, said in a lecture on platinum, delivered in 1861, "This substance has been given to us hitherto mainly through the philosophy of Dr. Wollaston."

In the process described by Wollaston the double chloride of platinum and ammonium was very carefully heated to a temperature just high enough to expel the ammonium salt, whereby the cohering of the resulting particles of metal was prevented. The product was then rubbed by hand, sufficiently fine to pass through a lawn sieve. It was then made into a uniform pulp with water, and this was placed into a brass cylinder, where it was powerfully compressed by means of a lever. The hard cake which resulted was heated on a charcoal fire, to expel the water and promote cohesion, and finally heated at the highest temperature attainable in a wind furnace. By forging the white-hot cake under a heavy hammer, it was consolidated into an ingot, which could be beaten into thin sheets and drawn into the finest wire. The refractory natural product had been conquered, and henceforth platinum was one of the useful metals.

That platinum is not infusible was shown in 1758, when Baumé and Macquer succeeded in melting grains of the ore by the aid of a concave mirror; but the melting of considerable quantities of the metal was a feat which was first accomplished in Philadelphia: in 1847 Robert Hare demonstrated that the difficult and tedious process of consolidating platinum sponge could be replaced by the simple operation of fusing the metal in the oxyhydrogen flame. He melted as much as 2 lb. of platinum at a time.

His process was greatly improved by the French chemists Deville and Debray, and it was through them that it became more generally known, and that it was adopted by the platinum refiners.

Deville's furnace consists of two well-fitting pieces of quick lime, hollowed out to form a crucible or hearth. An opening at the side serves as a spout for the molten metal and for carrying off the fumes and products of combustion. The nozzle of the oxyhydrogen blowpipe is introduced through an opening in the center of the cover.

Lime is used because it is infusible at the temperature of the flame, and because it is porous and absorbs the slags formed during the operation. It is also a poor conductor of heat.

I had the privilege of seeing this process in operation at the Heraeus works at Hanau. Although they used illuminating gas instead of hydrogen, it was amazing to see the platinum sponge and scrap melt like butter as fast as it was fed in. You cannot, however, distinguish the metal from the lime, as both glow with the same intensity, and one must also protect the eyes with dark glasses when looking into the furnace. At the Heraeus works I was shown all the principal operations, from the treatment of the ore with aqua regia, to the production of the ingot. Incidentally I also learned how such by-products as iridium, palladium, rhodium, and osmic acid are obtained and handled.

Although several methods have been proposed for the refining of platinum, it appears that the treatment of the ore in the different works is essentially the same; for there is little difference in the manufactured product, whether it come from London, Paris, Hanau, St. Petersburg, or our American refineries.

At the Heraeus works the ore is boiled under pressure with dilute aqua regia, whereby the platinum and some of the associated metals pass in solution in the form of chlorides, while the iridosmium and gangue remain undissolved. The chloride solution is evaporated to dryness and heated at 125 deg. C. The residue is then dissolved in water, acidified with hydrochloric acid and precipitated with sal ammoniac. The resulting double chloride, containing only small amounts of other metals, is finally reduced.

The refining of platinum in the dry way, as proposed by Deville and Debray, does not seem to have proved successful, except in special cases and on a smaller scale.

The preparation of chemically pure platinum, i.e., a product which is entirely free from iridium, rhodium, etc., is extremely difficult and tedious, and need not be discussed here.

Philadelphia, Pa.

Coloration of Fire Clay Products.*

Can the quality and the refractoriness of fire clay products be judged by their coloration? In answering this question it will be advisable to discuss the different factors which may affect the coloring of the burnt clay.

The iron content of the raw material is the great coloring agent of the clay, especially if its amount is high in comparison with the clay base; of further importance are the several impurities of the raw material, especially lime, the composition and temperature of the kiln gases and the density of the burnt ware.

Without regard to carbon deposits caused by a strongly smoky fire, or to superficial soiling produced by the ashes carried along by the kiln draft, the discoloration under circumstances enumerated will be influenced by the iron content of the raw material. The higher the ferruginous admixtures compared with the clay base the darker will be the color.

Since the iron oxide in a finely divided condition and combined with the other components of the clay serves as a flux, raw material showing high iron contents is not considered as a fire clay.

As there are no clays completely free from iron, discoloration produced by the ferruginous parts will always be observed. This same discoloration will occur in the manufacture of Dinas brick by using an iron-containing quartz, which, however, may be of sufficient refractoriness to burn to a useful brick. Although only materials containing very low amounts of iron are used in fire-clay manufacture, the iron percentage may reach as high as 2 per cent, whenever no other fluxing ingredients are present, and in case of a respectively high clay base.

Raw materials with different iron contents and of the same burn will show a difference in coloration without being necessarily different in quality. On the other hand it is possible that a brick of grayish-yellow color and another one of rust-color, both being of the same burn, may show a different refractoriness, and possibly the former may be more refractory. But according to the above remarks the color of the burnt clay cannot be considered to decide the quality of the ware as long as the bricks under comparison are not of the same burn.

The possibility of an examination of this kind is not given to the purchaser, but to the manufacturer this may suggest more thorough tests of the raw materials and products manufactured therefrom.

Concerning the influence of the fire gases, it has been observed that products burnt in an oxidizing atmosphere show every gradation of color from lightly pink to yellow, while products burnt in a reducing atmosphere show in general a more blackish coloration; red coloration may appear after reducing burning by the action of sulphur compounds. Other gradations of color may again occur when the atmosphere will alternately be reducing and oxidizing. The degree of temperature will also account for the gradation of color, so that it seems impossible to recognize the quality of refractory ware merely from the standpoint of its color.

The manufacturer alone may discover himself by a given tint whether one given burn differs from another one, other things remaining the same, i.e., the same composition of raw material and the same firing condition during the entire stage of burn-

*Translated from Tonindustrie Zeitung, No. 129.

ing. By taking into account the numerous gradations of color which may occur and on the other hand the widely varying iron contents of otherwise good refractory products it seems impossible to a person not acquainted with the manufacturing methods to make a true valuation, so far as color is concerned, solely based on the temperature of the burn.

As to the coloration as influenced by the density a dense body will be of darker color than a more porous body with equal iron contents. But to form an opinion as to the value of the ware in this respect would not be advisable at all, as the coloration may be influenced by one or more of the other numerous factors.

The question whether the quality and refractoriness of fire clay products can be judged by the coloration of the ware, must be answered in the negative. The products of the fire clay industry cannot be judged by their color because there are innumerable factors, which influence the discoloration of the ware. The technical properties are the only ones of value and they have to be determined by special tests and examinations.

Recent Researches on Corrosion of Iron and Steel.

In his report to the Manchester Steam Users' Association Mr. **C. E. Stromeyer,** chief engineer of the association, reviews the present situation in the corrosion problems as follows:

During the past year a considerable amount of important research work has been carried out with regard to the question of corrosion of iron and steel, and though it cannot be said that the mysteries of this complicated subject have been dispelled, much additional information is now available.

Practical experiences indicate that the internal corrosion of boilers is due almost entirely to the presence of air in the boiler water, or rather it is due to the oxygen and the carbonic acid of the air, which are absorbed by water when exposed to the atmosphere. This is a well-established fact, and Profs. Heyn and Bauer, of the Prussian National Physical Laboratory, evidently took it for granted, for they exposed their small experimental strips of wrought iron and steel in open breakers, which were partly filled with waters containing various proportions of corrosive and anti-corrosive salts. If these experiments on various salts are to prove of value to boiler users, the corrosive influence of the air must be reduced, and for this particular purpose it would have been highly desirable if the experiments had been conducted in an artificial atmosphere, with comparatively little oxygen.

However, as it is very desirable that these carefully conducted experiments on corrosion should be turned to advantage as regards boiler corrosion, the corrosive influence of air in feed water must be inquired into in order that its disturbing influence on the results may be discounted. In the experiments the average corrosion amounted to about 70 milligrammes in twenty-two days, which, taking into account the surfaces of the pieces, is equal to about 700 millionths of an inch of thickness in 120 days. Experimental corrosion of one-tenth of this the total, or, say, 70 units, should therefore correspond to very serious corrosion in a boiler, and the experiments, to be of value, should indicate to within 10 per cent of this amount, say, 7 units, whether the addition of a certain salt to any water will increase or decrease the corrosion. Unfortunately, the results do not come up to this expectation, for even among the experiments with distilled water the corrosion varies from 552 to 782 units, and individual results of two pieces of iron placed side by side under identical conditions, which ought to have corroded at identical rates, differed from each other by large amounts, in one case by as much as 158 units, or by twice as much as what may be considered serious boiler corrosion. By averaging results, however, certain indications are obtainable.

The object of the analysis of Profs. Heyn and Bauer's experiments was to ascertain whether any of the salts which they tried would be likely to counteract the corrosive tendency of the oxygen and carbonic acid which are introduced with the feed water. There is no great difficulty with regard to the carbonic acid, for almost any alkalis will neutralize it, but the oxygen can only be removed by letting it oxidize something, and that, no doubt, was the reason why, among other salts, deoxidizers were tried, but no additions were made of alkalies which would neutralize the carbonic acid in the solutions, though it is well known that most photographic developers (these are deoxidizers) require an alkali to make them active. It is, therefore, not surprising that no very pronounced results were obtained. Ferrous sulphate appears even to be an intensifier of corrosion, which may be due to its oxidation resulting in a ferric salt; but in a boiler where the oxygen supply would be limited, ferrous sulphate might be advantageous. A possible reason why weak solutions of sugar had a corrosive effect may have been that in the presence of an excess of air sugar is, perhaps, converted into an organic acid which would corrode iron, whereas with an excess of sugar there would not be enough oxygen in solution to effect this conversion and yet allow enough to remain for corrosive purposes.

The idea of making the oxygen harmless is often carried out in practice. The customary deoxidizers are, however, not salts, but organic substances, notably, tannin compounds. To be most effective they must be associated with an alkali, and it would be correct to introduce them continuously with the feed, then all the oxygen would disappear. The more economic plan, however, would be to maintain a slight excess of the deoxidizer in the boiler, for, as already explained, most of the oxygen escapes out of the water into the steam space, and need not be dealt with, and it is only the small residue which remains in the water that has to be removed. Of course, if the boiler circulation is bad and much stagnant cold water rests in the boiler's bottom, then obviously it would be best to introduce the deoxidizers continuously into the feed. That, too, is the only effective method for checking the internal corrosion of economizer pipes, if these are fed with strongly aerated feed water; but it is probably a costly process, for, after all, it is but a mere trace of the total oxygen in the water which does the harm, yet all the oxygen has to be removed if no harm is to be done.

Another plan is to keep the oxygen out of the feed water, which means that instead of feeding the boilers through the feed pumps of the main engine, which have to be excessively large and which necessarily pump air into the boiler, the feed should be dealt with by slow-running independent feed pumps; and perhaps the recent practice of marine engineers to use high-pressure centrifugal pumps for feed purposes may be equally advantageous. These centrifugal pumps offer the advantage that they require little driving power when the feed valves on the boiler are partially or entirely shut down.

Although the present experiments are somewhat disappointing, they do at any rate point to two very important conclusions which are confirmed by practical experiences. These are that most ammonia salts are powerful corroders of iron, which accounts for the serious corrosion sometimes met with in boilers fed with water that is contaminated with waste liquors from gas works, and, secondly, that when carbonate of soda is added to brackish water (water containing common salt) then severe pitting occurs, although the average corrosion may not be extensive. The protective action of oxidizing acids requires confirmation, if this be possible, by tests on boilers, and the well-known beneficial influences of deoxidizing agents require further scientific investigation.

Of late, certain salts and devices have been invented, which, although they aim chiefly at the reduction of boiler scale, may also counteract corrosive influences. The most sensational of these is the so-called "luminator," which consists of a sheet of corrugated aluminium over which the feed water has to flow under certain conditions of daylight. There seems to be no waste of aluminium, but the lime salts in the water, instead of

being precipitated as hard scale on the heating surfaces, are said to fall to the bottom of the boiler as fine powder.

"Permutit" is a double salt of the following composition: $2SiO_2$, Al_2O_3, Na_2O, $6H_2O$. If water containing lime salts be passed through a bed of this salt, calcium is retained there and sodium takes its place in the water. After a time the operation would cease, due to an excess of lime in the bed; then a stream of salt water is passed through it, and now the process is reversed, the sodium replacing the calcium in the bed of permutit, and chloride of sodium passing away. The bed can then be used again for the purification of feed water. The process is far too costly for the purification of waters containing chiefly carbonate of lime, for in addition to the first cost of the permutit, about 70 lb. of salt are required for the removal of 100 lb. of carbonate of lime.

If the water has permanent hardness (sulphate of lime), the case is more favorable, for every 100 lb. of this impurity would require 74 lb. of soda ash, costing 3s., for their removal in an ordinary softener, whereas with permutit experience shows that about 600 lb. of pure salt, costing about 4s., would suffice. It is, however, very rarely that the water supply has only temporary hardness, and as yet it has not been possible successfully to treat the water, first by the ordinary lime process for temporary hardness, and then with permutit for the permanent hardness. The difficulty seems to be that softened waters deposit lime in the permutit and choke it. Permutit is also not suitable for waters containing appreciable quantities of common salt.

Another very efficient but comparatively costly salt is aluminate of barium. It is preserved from atmospheric influences by being sent out in sealed tins, which must not be opened until required for use. The formula of this salt is BaO, Al_2O_2. The barium combines both with the carbonic acid and the sulphuric acid of the lime salts, forming insoluble precipitates; the lime is also precipitated as well as the alumina, the latter carrying with it most of the organic or greasy substances which may be present in the water. Water treated with this salt is, therefore, almost as pure as distilled water, and ought to be useful for washing purposes. As barium is somewhat poisonous, water purified by its means cannot be used for domestic purposes.

The Slime Filter Patent Decision.

A patent decision of greatest importance in connection with the cyanide process was rendered last month by the United States Circuit Court of Appeals for the Third District in the case of the Moore Filter Company versus the Tonopah-Belmont Development Company. The latter, using the Butters filter, had been sued by the Moore Filter Company for infringement of the Moore patents.

In the lower Circuit Court the decision was in favor of the Butters side. Judge Rellstat held that infringement of the Moore patents by the Butters filter was not shown. Thereupon the Moore Filter Company appealed and the Circuit Court of Appeals (Judges Gray, Buffington and McPherson sitting) has now reversed the decree of the lower court and remitted the cause "with instructions to enter a decree adjudging claims four and five valid and infringed."

Before giving details of the decision it is, therefore, well to quote here claims 4 and 5 of George Moore's U. S. patent 764,486 of July 5, 1904, on which the fight was made and the decision was reached:

Claim 4: "A filtering process comprising submerging a filtering medium in a material to be filtered, drawing the liquid being filtered from said material through said medium until a deposit of solids is formed upon the medium, removing the medium from the material being filtered, further impoverishing the solids by a cleansing operation, and removing the solids from the medium by passing a cleansing current through said medium."

Claim 5: "A filtering process comprising submerging a filtering medium in the material to be filtered, drawing the liquid being filtered from said material through said medium, removing the medium while continuing the drawing action, passing a cleansing fluid through the medium, and then passing a cleansing current through said medium."

Decision of Court of Appeals.

In the decision of the Circuit Court of Appeals, which is written by Judge Buffington, a review is first given of the difficulties formerly experienced in cyanide practice with the leaching of "slimes." Various articles written from 1892 to 1902 are quoted to show the seriousness of the slime problem until Moore offered "the first suggestion for the solution of this world-wide problem."

"After a careful study of Moore's patent, we have reached the conclusion that his process is a radical departure from the whole prior art and was an original and pioneer step in metal recovery by filtration. Like all important inventions its merit is its simplicity, and its novelty consists in his utilizing the simple elemental processes of nature. These processes he has, of course, neither discovered nor invented, but he has utilized them in combination in a manner never before used and has thereby secured a new result.

The Gist of the Moore Process.

"Briefly stated, the gist of Moore's instruction to the mining world was to filter an unleachable mass in such a manner as to cake the pasty slime so uniformly and evenly that the resistance of the slimy mass to percolation became uniform and even in every part of the cake. The result of such uniform and even cake-resistance was that when the cake was attacked by the percolating solvent its percolation was correspondingly uniform, and diffusive through the uniformly resistance cake. The solvent having by this uniform and even resisting been itself uniformly and evenly percolated through the mass, it followed that when this percolated solvent was in turn subjected to a propulsive washing current, that such propulsive current, finding no path of least resistance in the uniformly resisting cake or the uniformly percolated solvent, moved forward uniformly and evenly to expel such uniformly distributed percolated solvent. The creation of this uniform and even resistance in the cake is the gist of Moore's process, and such uniformity, as we shall see, is secured by the slime being submerged when subjected to suction."

Extended quotations follow from Moore's description of his process.

"Applying suction to a filter completely submerged is to form an enveloping case or cake of a pasty nature in the filter. As the cake builds up it develops a thickness and compactness which gives the entire cake a capacity of uniform resistance to percolation. For so long as the resistance is not uniform the consequent increased rate of deposit at that point would set up and continue until the rate of flow there became equal to the rate of flow at all other points. The significance of this uniform resistance capacity of the cake, and that it was obtained by filter submergence, is stated in the specification where the patentee, in order to show that after the filtering process is completed an entire enveloping cake of uniform resistance capacity can be simultaneously discharged by compressed air, says that such action is owing to the process having produced an enveloping cake of uniform and even resistance capacity."

"Indeed, of the fact that the result of subjecting a submerged filter to suction is an enveloping cake of uniform and even resistance, there can be no doubt under the proofs in the case. To question it is to dispute the operation of the laws of nature." Statements by two of the defendants' experts, Mr. Julian and Dr. Chandler, are quoted in confirmation.

Prior Art.

"It is contended, however, that the Moore patent is invalid by reason of the disclosures of the prior art. But in our view

this contention is based on a failure to recognize the true significance of what Moore really did. Practically his problem was to make commercially possible the recovery of a minute amount of valuable metal from a large quantity of mud. Of the fact of the metal being there, there was no doubt, for that fact, and indeed that it was possible to extract it, the tedious and costly method of laboratory filtration showed.

"It suffices to say that no one of the numerous patents cited did such work, used such process, or effected such results, and if none of them led their inventors or users to the use of any process whereby such work could be done, or even led to a suggestion in their descriptive matter of the possibility of the use of any such process as Moore's, it follows they taught Moore no more than others.

"So far as the patent here in question is involved, Moore's disclosure was the process he originated and not the machine with which he illustrated the use of his process in accordance with the statutory requirement that he file a written description 'of the manner and process of using it.' To find, therefore, here and there in prior patents, and disassociated from each other, all the mechanical appliances of the combination apparatus which Moore thus illustratively used is not to prove that Moore's process is not original."

"Viewed from a patent standpoint, the significance of a machine lies not in its form but in the principle on which it works, as will be seen in the requirements of 4888, 'in the case of a machine, he shall explain the principle thereof.' It suffices, therefore, to say that very few of these patents are even for a process, and as none of them operated on the principle or process of Moore, they cannot be held to forestall or minimize the originality of Moore's subsequent disclosure. And in giving these patents their due relation to Moore's disclosure the fact must not be overlooked that the slime problem which Moore solved only came into existence from the use of the cyanide process, which began, as we have seen, about 1887. It will, therefore, be manifest that no patents preceding that date and none subsequent thereto which did not apply to the cyanide process, were calculated to solve the cyanide percolating difficulties, that arose in the use of that process.

Laboratory Versus Industrial Practice.

"So, also, to say that following prior laboratory practice, it was possible to leach and extract the unrecovered ore left in a pasty mass by the cyanide process is not to destroy Moore's patent; for this is to lose sight of the practical working value of Moore's process as a workable, economic treatment, as compared with theoretical possibility of laboratory practice. By repeated dilution the laboratory could, and we will assume did, recover with practical completeness all such unrecovered metal, but this has been done with an expenditure of time, labor and expense out of all proportion to the value of the metal.

"When therefore Moore disclosed a process by which such recovery was made enormously profitable and by which he turned a dump heap which under all known processes, machines, and laboratory methods was worthless, into profitable ore, we are constrained to give little weight to the suggestion that his process was either anticipated, a mere advance incident to the art, or involved no invention."

Non-Diluting and Bodily Displacement of the Solvent Versus Diluting Intermingling.

"So, also, it is said that the step described in his claim, viz.: 'further impoverishing the solids by a cleansing operation,' was merely the washing or dilution of the prior art. Considered in its literalism and in isolation, such contention may seem plausible, but considered as a step in Moore's process it takes on new significance and value. Bearing in mind that in the prior steps of the process covered by this claim, the completely submerged filtering medium has formed a cake of uniform resistance at all points and by reason of such uniformity the solvent has percolated and is permeating the cake,

it follows that the step which follows is a non-diluting and bodily displacement of the solvent and not a diluting intermingling.

"This displacement in contrast with dilution, not only saves the time and expense of repeated dilution and refilling, but also obviates excessive dilution of the solvent solution and the necessity of rehandling large volumes of diluted solutions in the recovery of the metal. It seems, therefore, that the 'further impoverishing the solids by a cleansing operation' of Moore's process, owing to the prior step whereby a cake of even and uniform resistance is secured by submergence, is not a mere washing or diluting step, but is one wherein there is exerted a uniform pressure or pushing action through the entire cake surface, thereby in effect advancing a wall of water pressure to force ahead of it from the cake the value-bearing solvent liquid, and leave in the cake an equal volume of non-value-bearing water.

"This final result is secured by first having built up a cake of uniform resistance to solvent fluid flow, and secondly by again submerging the filtering medium and its built up cake in the non-value-bearing displacing fluid. By this displacement by pressure difference only Moore pushes ahead instead of washes through the cake contained-metal-carrying fluid. As showing the practically complete metal extraction by the Moore process, we restrict ourselves to the uncontradicted testimony of results at a South Dakota mine, where the original slime contained gold at the rate of $7.90 per ton of dry slime. After filtration alone the cake still contained $2.75 per ton of dry slime. After being then subjected to the displacement step there was left in the cake but four cents of gold per ton of dry slime."

Process Versus Apparatus Patents.

"Being of opinion, therefore, that Moore's process was novel, useful and inventive in character, his patent is valid and we next turn to the question of infringement.

"As claims four and five furnish sufficient basis for deciding that question, so far as the respondent's device is concerned and as some questions, not necessary to be here decided, exist as to claim ten, we restrict ourselves to a consideration of claims four and five.

"In considering the question of the infringement of a process patent, it must be borne in mind that the monopoly secured by the claims is, generally speaking, a monopoly of the process and the test of infringement, is whether such process is utilized by the infringer. As the apparatus shown in a process patent is only to show that the process may be practically applied, it follows that such illustrative apparatus does not limit the process patentee to that type of machine alone. If that were the case a process patent would be of little value.

"So distinctively and separate in the patent law are process and apparatus for utilizing such process that where, after a patent for a process by one inventor a second inventor might patent a novel apparatus for utilizing the process, the situation would arise that the inventor of the process could not employ his process in such machine without license from the machine patentee and the latter could not use the process in his machine without license from the process patentee.

"It will therefore be evident that the test of process infringement is not the similarity of apparatus, but rather whether the apparatus, no matter what its form, utilizes the process. Tested by this standard it is clear to us the respondent's device infringes."

Essentials of a Process Versus Details of Apparatus.

"In form the particular apparatus shown in Moore's patent and the apparatus of respondent vary in the number of tanks, in the differences between changing the fluid which envelops the filtering medium, as in respondent's device by allowing the filtering medium to remain stationary in one tank while the submerging fluid is first drawn off and the second submerging bath is then drawn into the same tank, while in Moore's the

filtering medium is raised from the submerging bath in the first tank and then lowered into the second submerging bath in a second tank.

"But this difference in numbers of tanks and of respective withdrawal and replacing of different baths in no way affects the identity of the process, for it is manifest that Moore could in his patent specification have shown the use of his process, just as well by using respondent's apparatus, had he known of it as his own.

"Both alike use the principle of submergence and intra-leaf suction to create the uniform and even resistance of the cake and both alike use the principle of intra-leaf pressure, Moore using air and the respondent water, to shed the uniformly resisting cake from the filter. For the mere fact of the output being carried off as a dry product in Moore's case to a dump heap and in respondent's in fluid form to a slime pit, does not go to the substance of the process. In the essentials that involve the invention the two are alike.

"Had an apparatus such as respondent's, operated as it is, been in use prior to Moore's there would have been no invention either in the process or in the apparatus shown in Moore's patent. And what, if preceding a patent, would have anticipated it, equally infringes if subsequent. We therefore hold the fourth claim is infringed.

"As we are of opinion and so find from the proofs that there is in respondent's device a 'removing the medium while continuing the drawing action,' the fifth claim is also infringed.

"The decree of the court below is therefore reversed and the cause remitted with instructions to enter a decree adjudging claims four and five valid and infringed and for such action by that court in the way of injunction and accounting as it shall deem fitting."

Hydraulic Classification.*

By G. A. ROBERTSON.

Although numerous methods of classification of pulp for tube milling have been introduced on the Rand within recent years, the spitzlutten in series is still commonly used, and provided it is adjusted to local conditions, good results are obtained. A common error in the lay-out of a spitzlutten lies in the grade of the launder leading from the tailings elevators to the V-shaped or pyramidal boxes being too great, and, together with the impetus given the stream discharging from the elevator, makes difficulty in getting full command over the velocity of the stream through the boxes. This difficulty can, however, be overcome by heightening the box in the last compartment of the series by having a slot above the overflow lip and sliding into this slot the necessary height of wood to reduce the velocity of the stream, this wood traversing the stream. Another method often overlooked is nature's good old rule that the velocity of stream decreases in the inverse proportion as it widens out. Under certain conditions where the first-named method may cause sand to bank in front of the boxes, it may be found advantageous to cut pieces out of the launder on each side of the spitzlutten and widen the stream, commencing a few inches below waterline at the first box. Only fine grades of sand take the extended route, thus allowing better settlement of the coarse sand within its travel zone. The conditions of classification remain fairly constant in this type of classifier. Owing to the small underflows, however, necessary for efficient work, they are liable to choke; but this can be reduced to a minimum by a suitable arrangement of screening in the launders before and after the elevation of pulp.

Adjustment to Variations in Feed

A classifier giving a liquid underflow adjusts itself better to changed conditions than a classfier that gives a low ratio of moisture to solids. For instance, cones, cylinders, V-boxes,

pyramids, and other types of classifiers used in series for classifying pulp prior to thickening in a dewaterer, will give, say, from the first box 150 tons of solids per twenty-four hours containing 60 per cent moisture. If the feed is increased, the same size of nozzle may give 200 to 250 tons of solids in the underflow, containing between 40 and 50 per cent moisture. Obviously, the volume of solids in the underflow increases at the expense of reduced moisture. On the other hand, take a diaphragm classifier giving an underflow of 300 tons of solids per twenty-four hours containing 27 per cent moisture. If the feed to the classifier be increased, the moisture cannot be reduced more than 1 per cent, and the a coarser overflow is inevitable. Experiments are being conducted with a view to overcoming this difficulty, and a fair measurement of success has already been obtained on one mine, the idea being to automatically increase or decrease the diameter of the underflow nozzle in accordance with the load. Hanging up stamps at week-ends is responsible for the settled sand in such classifiers breaking away, unless the reduced load has been noticed and the underflow adjusted accordingly. On another mine a ball suspended centrally in the classifier has proved its merits by steadying the underflow and permits the depth of settled sand being kept at a low level in the classifier consistent with a low ratio of moisture in the underflow.

Where a diaphragm classifier is used as a separator of sand from slime, an automatically regulating underflow ought to be welcomed. There may be objections to the same idea for tube-mill classifiers, but I think that it is better to underfeed a tube mill and allow for its taking an increased load rather than have constant conditions in the classifier underflow and coarse sand overflowing the classifier without the tube mill having been tried on the increased load.

Instead of diluting a thick underflow after its leaving the classifier, a good plan is to have a stream of water just below the diaphragm. The necessary moisture for tube milling can thus be added inside the classifier from a 1-in. pipe attached to a rubber hose and water service. The required moisture for the underflow is then regulated from a valve, and the pipe can be lowered and raised to the most suitable height. The nozzle can be reduced to $1\frac{1}{4}$ in. diameter, and the underflow is discharged at a high velocity. On one mine this method has proved very satisfactory, more so than adding water to the discharged pulp.

Classification for Tube Milling

Changes in the feed and moisture entering large conical classifiers under working conditions sometimes cause sand to bank up in these classifiers, thereby forming a "dead end" and decreasing the capacity of the cones available for classification. This is particularly noticeable where a tube-mill plant is working at fullest capacity and giving a medium-grade overflow from the classifiers of about 15 per cent plus 60 grade pulp, or the equivalent to that which would pass a 1200-mesh screen in single-stage crushing. On the other hand, however, where a fine overflow is desired of about 5 per cent plus 60 grade, and under, the tube-mill classifier is encroaching upon the province of a separator of sand from slime, for which it is an ideal machine, and no appreciable "dead end" is formed. This depends to a great extent on the number of tube mills to stamps and the ratio of solids to moisture leaving the stamps. Of course, sand held in suspension in classifiers can be prevented by increasing the size of the underflow, but as far as tube milling is concerned, classification of pulp is the sorting into a limited tonnage of that portion of pulp desired for recrushing, and in that respect I have sometimes been puzzled to see where classification came in at all when between 400 and 450 tons of solids constituted the average feed per tube mill. These large tonnages are claimed to give the best results on some plants, while on others a tube-mill feed not exceeding 300 tons gives the best results. Where amalgamation is not practised in the stamp mill, nor in the classifier overflow, the larger feed to the

tube mills the greater the percentage of gold recovered by amalgamation in the tube-mill circuit.

In order to overcome the difficulty of fine sand resettling and silting up classifiers, the classifier designed by Mr. H. Stadler is undoubtedly an improvement on the ordinary cone. At the bottom of the central feed pipe to this classifier the area of the cone is greatest, so as to allow settlement of the solids from the level of release of the pulp into the classifier. From that point, having sorted out that portion of solids required in the underflow by means of a truncated cone, the velocity of the upward stream is gradually increased, thereby preventing "dead ends," which otherwise are formed in the ordinary cone by the decreasing velocity of the upward stream.

Even Distribution of Feed.

A cone centrally fed and having a horizontal baffle on the bottom of the feed pipe does not give an even distribution of feed into the cone. In order to see this, however, the cone has to be working at fullest capacity. Further, air is carried down the feed pipe into the cone, and it rises to the surface in the form of air bubbles, bringing coarse sand with it, which, if near the overflow lip and not confronted with a baffle, causes coarse sand to pass in into the overflow. Some mines employ a sleeve around the feed pipe to catch the air bubbles. On the ground that if no air was carried into the liquid none could rise to the surface, the writer placed an iron plate partly over an 8-in. feed pipe to a diaphragm classifier. The conditions allowed a 20-in. "head" being obtained over the feed pipe. No air was then carried down, and the overflow level of the classifier was free from air or other disturbances. The feed to the classifier was increased, still keeping the 20-in. head, and it was seen that the distribution of feed to the cone was not even, thereby causing at intervals upward currents of coarse sand which were free from air. In order to get better distribution into the cone and still prevent air from getting into the classifier, a better method was to maintain the "head" from the bottom of the feed pipe. Mr. C. W. Dowsett then applied a self-regulating device which consisted of a circular plate, 7 in. in diameter, with three lugs projecting upwards. These lugs acted as guides when the plate rested on the horizontal baffle at the bottom of the feed pipe. This plate was then suspended from a bolt which went to the top of the launder, and was attached to a horizontal piece of wood 2 in. wide, ½ in. thick and 6 ft. long. One end of the wood was made fast to the top of the launder, while the other end suspended the bolt carrying the lugged plate. With a normal feed, the lugged plate was about 1 in. above the horizontal baffle, and a head was obtained from this point up to 20 in. above the inlet of the pipe. As the feed increased, the lugged plate was forced downwards, thereby increasing the release area of the feed pipe and allowing a greater feed to pass into the classifier. Similarly, as the feed decreased, the lugged plate rose and the "head" remained constant within certain limits. Owing, however, to the limited area of the cone at the bottom of the feed pipe and the increased velocity of the feed caused by maintaining the "head" already referred to, together with a slight unevenness in the distribution of pulp into the cone, the tendency is for settled sand to be distributed, thereby causing upward currents of coarse sand. The distributing shoe used in the Stadler classifier would appear to overcome this difficulty, and even though the air may be carried down the pipe, it is in a fine state of division in the classifier and classification is not retarded by its presence.

A change from one classification system to another does not mean that finer overflows are to be obtained by the new classifier. If, however, the assay value of the overflow has been reduced by the new system of classification, then it can be safely said that improved classification has been obtained.

Classification in Grinding Pans.

The swirl of pulp from centrifugal motion of the shoes in a grinding pan causes the surface of the liquid to keep a con-

cave shape, and the particles of sand, on being crushed, rise in the liquid, the tendency being for these fine particles to be forced to the periphery of the pan. In order to obtain advantage of this classification, the discharge of such pans should be from the perimeter. This is easily understood, but not always realized, because the Holman grinding pan, which was tested on the Rand five years ago, did not prove a success, a contributory factor to its failure being that the discharge of the pan was upon a wrong principle. This pan had a peripheral inflow and central discharge through a perforated reversed cone. The design of the pan necessitated a peripheral feed, but that was no reason for a central discharge, which was fundamentally wrong. The discharge could advantageously have been placed on the perimeter opposite the inflow.

Separation of Stamp-Mill Pulp and Tube-Mill Pulp.

Two elevations of pulp are often required in new milling plants. There is no occasion, however, for the two elevations of pulp for purely classification purposes, because the stamp-mill pulp and tube-mill pulp can be kept separate with only one elevation of pulp. The best classification of pulp is obtained where these products are kept separate, but this is only marked where medium grade overflows of about 15 per cent plus 60-grade pulp is desired.

The tendency is for new milling plants to produce about 60 per cent slime, and in that case classification of pulp is almost a separation of sand from slime, and it is doubtful if any improvement in classification by keeping the stamp-mill pulp and tube-mill pulp separate by double pumping would be offset by the cost of the second elevation of pulp.

Mixing nine-mesh products and tube-mill outflows in the same classifier is wrong in principle, because different sizes of particles have different velocities, as pointed out by Mr. R. Boss,[1] and the tendency in hydraulic classification with mixed feeds is for the light material to follow in the path of the coarser particles.

Put to a practical test Mr. Boss's observations, but instead of dropping pebbles into the same glass vessel, have two vessels. Procure fine particles of quartz and particles of pyrites of equal value, and note their difference in the time for settlement in separate vessels. Also test mixed feeds in one vessel.

The only conclusion the careful observer can arrive at is that, in order to get the best results in classification, each grade should be sized and fed to a separate classifier. When this proposition becomes economical, it will be possible to obtain from separate overflows products which, after dewatering, contain neither pyrite nor gold. It is, of course, possible with present methods of classification to obtain a plus 60 grade product which contains but little pyrite or gold, as recently pointed out by Mr. H. Stadler in a rather spirited article, "The New Metallurgy," which appeared in the *Rand Daily Mail*. Only a very limited percentage of the total ore crushed could be obtained of this class. It is apparent, however, that while development takes place in the cheapening of the means of ore crushing whereby the sand is separated to be then slimed, there is still a wide field for research in hydraulic classification. No metallurgist will then want to cyanide barren sand.

Application of the Moore Filter to Rapid Filtration and Purification of Sewage.

On November 20 we had an opportunity of witnessing a very successful exhibition of a new sewage purification process at the laboratory of the Moore Filter Company in New York City, at which representatives of the water departments of various Eastern cities were present.

It is essentially an application of the well-known Moore filter to rapid sewage filtration. The chemical features of the process are the invention of Mr. James M. Neil. We expect to give a full description of the process in our January issue.

[1] "Segregation of Solids in Liquid," Mining and Scientific Press, September 9th, 1911.

The Role of Alumina in Copper-Slag Formation.

The mooted question of the part played by alumina in the formation of slag in copper smelting was referred to in our issue for October, 1912, page 693, where we gave an abstract of an address by Mr. H. C. Bellinger, president of the Australasian Institute of Mining Engineers. Mr. Bellinger related his experiences in several countries, among others Canada. We are able to present the following additional notes on Canadian experience, relating to the same ores with which Mr. Bellinger had to deal about a decade ago. The discussion is contributed by Mr. J. Buchanan, metallurgist for the Consolidated Mining & Smelting Company, of Canada, Ltd., at Trail, B. C., and Mr. F. E. Lee.

"The subject of the behavior of alumina in copper slags has of late been given much attention at the smelting works of the Consolidated Mining and Smelting Company, of Canada, Ltd., at Trail, British Columbia, and while we have not yet arrived at any definite conclusion in regard to its behavior in our slags, we have worked out a formula which gives very satisfactory results in our case.

"Taking an average monthly slag with the following composition:

FeO	SiO$_2$	CaO	MgO	Al$_2$O$_3$
16.1	44.0	19.2	2.5	17.4

(1) Figuring alumina as acid oxygen, ratio is 1:3.14.
(2) Figuring alumina as basic oxygen, ratio is 1:1.28.
(3) Figuring alumina as neutral oxygen, ratio is 1:2.33

"It will be seen that in case (1) we have an impossible slag, in case (2) a slag which appears too basic, judging from the appearance of our slag here, and case (3) is slightly on the acid side.

"In our calculation we assume that the CaO present combines with the requisite amount of Al$_2$O$_3$ to form the silicate of lime and alumina with the composition Al$_2$O$_3$, 3 CaO, 6 SiO$_2$, this alumina acting, of course, as a base and any excess over the amount required for this formula will act as an acid.

"Figuring the above slag on this basis, we have:

	Per cent.	Units O.
SiO$_2$	44.0	23.47
Al$_2$O$_3$	17.4	8.17
CaO	19.2	5.49
FeO	16.1	3.57
MgO	2.5	1.00
	99.2	41.70

"Leaving one oxygen equivalent of Al$_2$O$_3$ to one of CaO on the basic side and moving the balance of the Al$_2$O$_3$ oxygen to the acid side we have:

	Acid.		Base.
SiO$_2$	23.47	CaO	5.49
Al$_2$O$_3$	2.68	Al$_2$O$_3$	5.49
		FeO	3.57
	26.15	MgO	1.00
			15.55

which gives ratio base to acid 1:1.68, a good economic slag.

"Figuring all the slags mentioned in Mr. Bellinger's article on this basis, the result is a good practical slag in each instance and similar results have been obtained from calculations on many other slags which have come under our notice.

"Our experience here is that the amount of alumina acting as a base is determined by the amount of lime present in the slag, and the addition or subtraction of lime to or from the charge beyond certain narrow limits proves this to be the case. It is quite probable that some other bases may act in the same capacity as lime."

In this connection two A. I. M. E. papers by Mr. Johnson and Prof. Fulton, noticed elsewhere in this issue, are interesting.

Recent Copper Milling Practice at Lake Superior.

Editorial Correspondence.

The "copper country" of Michigan is confined to a small area of land known as the Keweenaw peninsula, jutting out into the center of Lake Superior from its south shore. The concentrating mills of the district are grouped at various points of vantage on the lake shore, where the large volume of water required by local practice can be conveniently obtained, and where suitable dumping places are available for large quantities of tailings. The map shown in Fig. 1 gives an outline of Keweenaw peninsula, and the numeral references show the situation of the principal groups of mills and smelters.

In general, the practice of concentrating the metallic copper ores of Michigan is fairly well known. Here the steam stamp has been developed to its highest degree of perfection, being found indispensable in crushing the tough, unyielding rock in which the copper has been deposited. The metal is recovered in a variety of forms and sizes, from the huge masses weighing many tons each, to the smaller masses of several pounds weight which are sorted out ahead of the stamps, ending with the coarse metal and metallic slime produced by the jigs and tables. It can readily be imagined, therefore, that many features of the milling practice have been developed to meet the distinctive local conditions which prevail in no other copper producing district in the world.

Modern Steam Stamps.

In Fig. 2 is shown the Nordberg type of steam stamp which is now being used in the newer installations. These stamps are of the steeple-compound type, with cylinders mounted on round column framing of very rigid construction, and standard mortar with solid anvil blocks below.

The low-pressure cylinder is placed above the high-pressure, and connected thereto by means of a distance-piece of cast iron, giving access to the stuffing-box. The high-pressure cylinder is also mounted on a distance-piece, for the same purpose.

The cylinder heads are so constructed that they will break out in case they are struck by the pistons, thus saving the balance of the machine from destruction in case of such accident.

The low-pressure cylinder is provided with Corliss valves at top end only, for the downward stroke. The high-pressure cylinder has valves at both ends, the lower valves controlling steam admission and exhaust below the high-pressure piston for the purpose of raising the stamp shaft, etc.

The valve gear is of Nordberg patent type with double disc differential motion. There are six eccentrics, one for each valve, the eccentrics driving the lower high-pressure valves and the low-pressure valves being mounted on the pulley shaft, while those driving the upper high-pressure valves are mounted on the secondary shaft. Graduating dials are provided for each eccentric, indicating the position of their central lines relatively to each other. By this arrangement it is expected to get a higher economy in steam than with the old arrangement now used, this economy resulting mostly from a free exhaust at the bottom, whereby the vacuum carried by the condensers can be more fully realized on the stamp piston than with the arrangement where only one valve is used to control the distribution of steam at the lower end of the cylinder. It is also plain that by this arrangement a more delicate adjustment of the steam distribution to both ends of the stamp can be obtained than by a two-valve arrangement.

The bearings on which the secondary shaft is mounted are fitted to a slide wherein they can be adjusted in such a manner that the ratio between the fast and slow motion can be varied between wide limits.

The flywheel on valve-gear shaft is turned on rim and edges, and adapted for belt drive. No loose pulley is used in connection with this arrangement, but it is expected that a tightener will be employed to stop and start the valve motion. Arrangements are made whereby the admission to the top and bottom

of cylinder can be independently controlled. A reheating receiver is provided between high-pressure and low-pressure cylinders.

Pistons are made of cast steel with cast-iron packing ring. Piston rods are of forged steel with flange at lower end connecting to stamp bonnet. The bonnet, or connection between piston rod and stamp, is fitted with a cushioning disc of rubber. Stamp shaft guides are formed in the framing and are fitted with phosphor-bronze boxes, arranged so as to be easily and quickly removed.
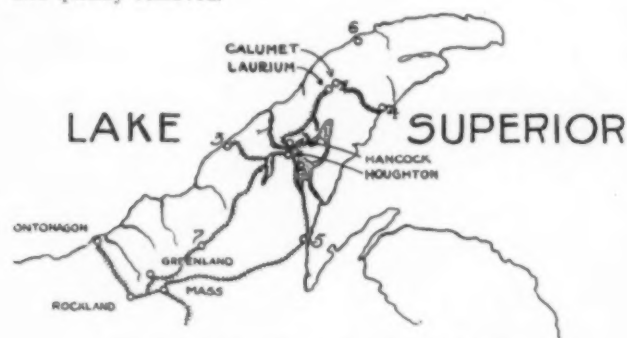

FIG. I.—KEWEENAW PENINSULA, MICHIGAN.

1 *Torch Lake.*	Quincy Smelter	5 *Keweenaw Bay*
Calumet & Hecla		Mass.
Ahmeek	3 *Redridge*	Michigan C M Co.
Lake Superior S. Co.	Champion	
Osceola	Trimountain	
Quincy Mill	Baltic	6 *Eagle River*
Tamarack	Adventure	Phoenix
	Atlantic	
2 *Portage Lake*		
Franklin	4 *Traverse Bay*	
Lake M S & R Co.	Mohawk	7 *Winona*
Isle Royale	Wolverine	Winona & King Philip
Michigan S. Co.		

The Importance of Regrinding.

The copper ores of Michigan are not high grade, averaging perhaps 1 per cent copper. The following table gives the copper content of the ore from several of the prominent mines of the district.

	Copper Lb. per ton.
Calumet & Hecla	25.5
Ahmeek	24.7
Allouez	16.5
Centennial	17.3
Isle Royale	16.4
Tamarack	19.1
Baltic	22.1
Champion	21.3
Trimountain	17.6
Hancock	18.2
Mass	17.6
Mohawk	15.1
Quincy	16.1
Wolverine	23.4

In view of these conditions it becomes necessary to carry copper extraction to the farthest point consistent with profit. and it is not surprising that in the last few years a great deal of attention has been given to the matter of finer grinding and additional concentration. The newer mills are carrying out this idea as part of the general scheme, while the older plants are being equipped with regrinding departments for current and accumulated sand tailings.

The Chilean mill was first used as a regrinding machine. The most notable installation was made at the Calumet & Hecla mills on Torch Lake in 1909, at a cost of about $400,000. The equipment consisted of forty-eight Chilean mills arranged in two rows and driven by eight 250-hp motors. Two hundred Wilfley tables concentrated the reground pulp. This plant proved its ability to re-treat current sand tailing at a profit. In

1910 the recovery was reported to be 5 lb. copper per ton of tailings, at a cost of 5 cents per pound of metal recovered. The sands treated contained up to 12 lb. copper per ton, being the tailings from the stamp units treating high grade ore in the Calumet mill.

Following the successful treatment of current tailings, the accumulations of old tailings received attention, and their retreatment was considered. In the early days of Calumet & Hecla, the grade of the ore was three or four times as high as at present, and the tailings likewise were richer. Possibly some of them were equal in grade to the original ore now treated. These old accumulations are the most extensive in the world, aggregating probably 40,000,000 tons of material containing from 10 to 25 lb. copper per ton, the older being probably the richer.

Before building a new plant for the treatment of these tailings, the merits of different regrinding machines were tested over a long period of time. Standard tube mills and Hardinge conical mills were placed in competition with the Chilean mills, with the result that the Hardinge mill was demonstrated to be best adapted to the work. Tests on the old tailings showed that a recovery of about 5 lb. copper per ton could be made profitably; and a new regrinding plant of Hardinge mills is now being built, to have a capacity of 3000 tons per day. Further reference to the use of regrinding will be made in the following description of one of the newest mills.

The Ahmeek Mill, Hubbell, Mich.

The Ahmeek mill is situated on the west shore of Torch Lake, near the town of Hubbell and south of Lake Linden, where the Calumet & Hecla mills are built. It is one of the newest mills of the district and reflects modern methods of construction, being built wholly of structural steel and concrete. It is particularly interesting because it gives an opportunity to compare former and later practice. Work was started in 1910 with two stamps, and later the capacity was increased by the addition of two more stamps in 1911. Two systems of concentration were thus installed with two stamps at the head of each. The essential differences between these two systems will be pointed out later. According to present plans four more stamps will be added in 1913, with concentrating units modeled on the later practice, and the two older units will be changed to conform thereto.

Capacity of Bins and Stamps.

The mill building is connected with the Mineral Range railroad by a steel trestle which reaches a height of 108 ft. at the mill. Ore is brought into the mill over this trestle and dumped into four steel bins, one for each stamp. The bins are quatrefoil in horizontal section, their largest diameter being 30 ft. and their height 42 ft. Each has a capacity of 1000 tons of ore. From the bins the ore flows by gravity to the stamps, which are of the pattern already described. Mass copper is sorted out by hand as the ore passes through the feed chute. The stamps make 106 strokes per minute and are provided with a signal which warns the operator when the bed of ore on the die is becoming too thin for safety. The high-pressure cylinder receives steam at 140 lb., and the low-pressure cylinder at 35 lb.

The capacity of these stamps is tremendous to one who is familiar only with the gravity stamp which is such a common machine in western gold mining regions. Those at the Ahmeek crush 625 tons of ore per day each, with far less noise and vibration than would accompany the operation of a 50-stamp gold-mill. The mortar boxes are fitted with two screens, steel plates punched with $\frac{5}{8}$-in. round holes, placed in front and back. In the ordinary course of operations these plates last about three weeks. The stamp shoes weigh about 700 lb. when new, and have a useful life of about 13 days. At the end of that time they are worn to a weight of from 300 to 325 lb. and are removed.

The mortar boxes are fitted also with a device for removing mass copper of fist-size and smaller, which may have escaped the eye of the feeder, or may have been liberated from the

rock by the stamp. This consists of a pipe connection with the
mortar box, through which water is forced into the mortar
under such pressure that the copper can pass down the pipe
against the stream, while the lighter rock is restrained and kept
in the mortar for further crushing. These hydraulic mortar-
cleaning devices are of great assistance in maintaining the
capacity of the stamp by removing metal which it would be
useless to try to crush, and by rendering it unnecessary to open
the mortar for periodical cleaning by hand.

Earlier Concentrating Practice.

The 5/8-in. mortar discharge flows from the stamp to four
hydraulic cleaners similar in principle to launder classifiers and
serving the same purpose as the hydraulic mortar cleaner.
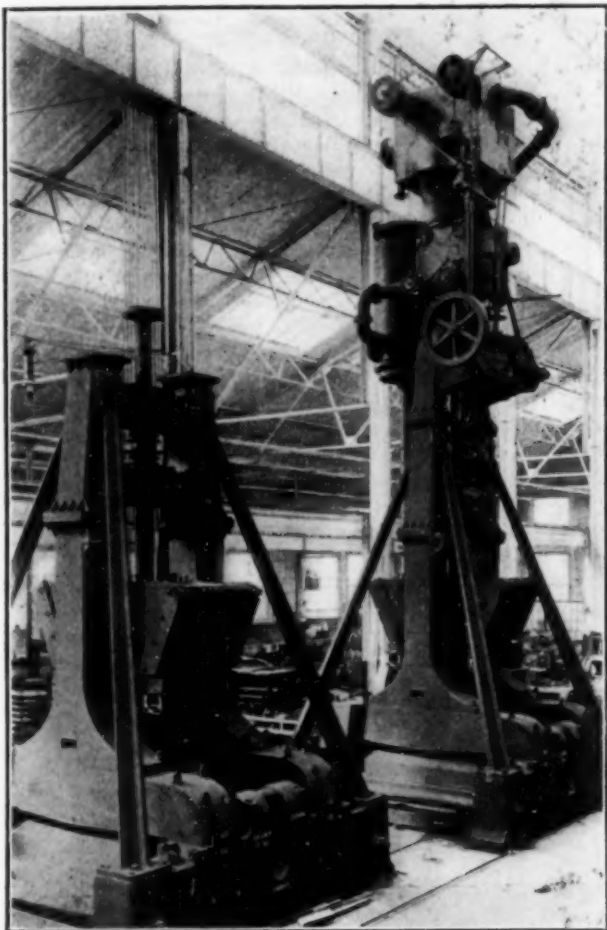These remove coarse metal, 5/8 in. and smaller, as concentrate

FIG. 2.—NORDBERG STEEPLE—COMPOUND STEAM ORE STAMPS IN
COURSE OF ERECTION.

for shipment. The balance of the pulp passes on to four
conical trommel screens of 3/16-in. mesh. The oversize of
these screens is returned by elevator to the stamp for further
crushing. The undersize is again subjected to hydraulic treat-
ment after which the pulp is distributed to jigs.

This hydraulic treatment is one feature which has been
abandoned in the newer half of the mill where, according to
later practice, the same work is better done by Woodbury bull
jigs. An objection to the hydraulic system is found in the
fact that, owing to the high water pressure required to keep
rock from mingling with the removed copper, smaller pieces
of metal remain in the pulp and pass on to the jigs, burdening
them unnecessarily and necessitating undue skimming. Fur-
ther, the product of the hydraulic discharge is not as clean
copper as that produced at the corresponding point by the
Woodbury bull jig. Again, the oversize of the trommel which

is returned to the stamp is not as free from copper as is the
bull jig tailing, and as a consequence some copper is kept cir-
culating through the stamp, with probable loss of metallic slime
due to abrasion and comminution.

Roughing and Finishing Jigs.

Taking up again that portion of the pulp (minus 3/16-in.
mesh), which flows to the roughing jigs, we find it first hy-
draulically classified into four spigot products and a slime
overflow. The jigs are arranged in sets of four two-compart-
ment machines, each receiving one of the spigot products from
the classifier. There are eight sets of these jigs, or thirty-two
in all. They run at about 160 r.p.m., the stroke varying from
1/4 in. to 1 in. on the different feeds. The screens vary from
8 to 14-mesh. The plunger mechanism is arranged to give a
quick pulsion stroke with slower return.

The roughing jigs are skimmed every two hours to remove
the accumulation of coarse metal which escapes removal in the
hydraulic separators. The hutch material is not a clean con-
centrate and is re-treated on a set of Hodge finishing jigs. As
there is no regrinding apparatus on this side of the mill, the
tailings from the roughing jigs are run to waste.

The finishing jigs run at a higher speed than the roughers
and have shorter strokes. Their tailings are run to waste. The
concentrates from the first compartments are clean enough for
shipment, but those from the second compartments are re-
treated, half going to another jig and half to Wilfley table. The
tailing from this last jig also is treated on the Wilfley table,
which makes concentrate and tailing, the latter being wasted.

Treatment of Slime.

Several slime pulps from different parts of the system are
collected, thickened and treated on tables. The overflow from
the classifiers at the roughing jigs is thickened and classified
into two products. The fine is sent to six Evans 3-deck revolv-
ing round tables, having smooth pine decks revolving about
once per minute. The concentrates from these round tables
are re-treated on two Wilfley tables which make concentrates,
middlings and tailings. The middlings are combined and
treated on another Wilfley, and the tailings are wasted. The
coarse slime from the classifier is treated on four Wilfley
tables, making concentrates, middlings and tailings. The mid-
dlings are retreated on a fifth table and the tailings are wasted.

Later Concentrating Practice.

The principal points of difference between the later and
earlier methods are (1) the use of Woodbury bull jigs instead
of hydraulic separators, (2) the regrinding of jig and tables
middlings, (3) the abandonment of the Evans round tables, and
(4) the use of Woodbury slime classifying jigs instead of
hydraulic classifiers and Hodge roughing jigs.[1]

The west half of the mill, with two stamps, typifies recent
practice. The 5/8-in. stamp product flows directly to four
conical trommel screens of 3/16-in. mesh, similar to those on
the other side of the mill. The oversize from each pair of
trommels is combined and treated on a Woodbury bull jig
from which coarse copper is withdrawn from a central gate
and dam on the screen. The tailing is returned to the stamp
by an elevator, and the hutch product is sent to finishing jigs.

The superiority of this method of recovering coarse copper
has already been touched on in speaking of the deficiencies of
the hydraulic method used in the other half of the mill. The
jig concentrate is cleaner metal than is obtained in the hydraulic
discharge, and the jig tailing which is returned to the stamp
carries less free metal than does the corresponding material in
the older system.

Slime Classifying Jigs.

The 3/16-in. undersize from the trommels flows to four
Woodbury slime classifying jigs, comprising a slime-classify-
ing compartment and three jigging compartments. The classi-
fier compartment has 10-mesh screen and the jig compartments

[1]An article on the Woodbury system of classification and jigging ap-
peared in this journal, November, 1912, page 759.

12-mesh. The classifier effectually removes slime from the pulp as can be seen by inspection of the jigs and tables which follow it, these being freer from slime than the corresponding machines on the other side of the mill. The other products of the classifier are copper concentrate and sand. The copper is removed continuously by gate-and-dam discharge, and the sand flows to the jigs.

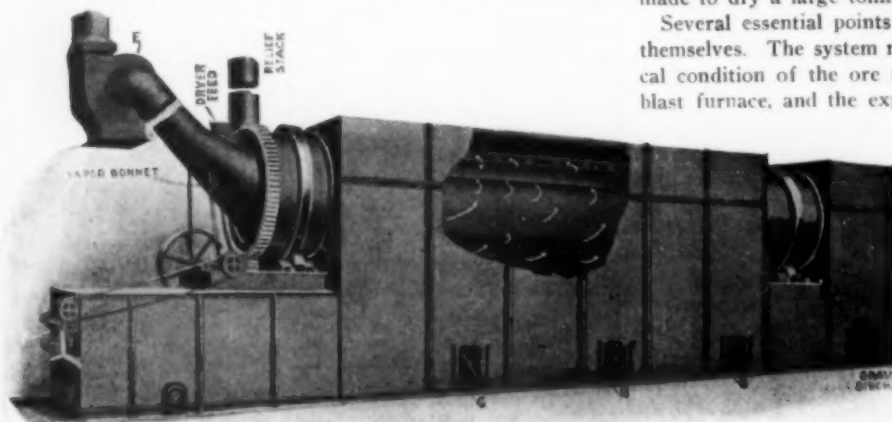The first jig compartment produces copper and the second and

FIG. I.—DRYER WITH STEEL HOUSING AND FAN.

third compartments deliver a middling through an adjustable opening in the lower side of the compartment which permits only the bottom portion of the bed to pass out. These middlings are combined and reground in a belt-driven Hardinge conical mill containing 7500 lb. pebbles and consuming about 100 lb. pebbles per day. The tailings from the rougher jigs are wasted, but the hutch material is combined with a similar product from the bull jig and classified for treatment in Hodge finishing jigs which make screen and hutch concentrates, and tailings.

Table Concentration of Sand and Slime.

The tailings from the finishing jigs are treated on four Wilfley tables. The middlings from the latter are combined on a fifth table, the tailing and middling of which are reground in a second Hardinge mill. The products of both Hardinge mills are treated on six Wilfley tables. These make concentrates of shipping grade, tailings which are wasted, and middlings which also are treated on that table which sends its middling and tailing to the second Hardinge mill.

The slime from the Woodbury classifier is treated on twelve Wilfley tables the middlings from which are treated on one middling table which makes concentrate and tailing.

All tailings except those from the lowest tables in the mill run to Torch Lake by gravity, being sampled automatically in a small building outside the mill. The cement floors of the mill all drain to a common sump from which slime is periodically removed and run over a concentrating table.

On the whole, the newer practice is more satisfactory than the old, for reasons already mentioned; and it is probable also that the recovery is slightly greater by reason of the more prompt recovery of coarse metal and the re-treatment of reground middlings and tailings.

High Speed Iridium Steel.

The latest achievement in high-speed tool steels is recorded by the Becker Steel Works, of Crefeld-Willich, Germany, in a full-page advertisement in the *Kölnische Zeitung*.

It refers to the use of iridium for high-speed steel and high claims are made for it. The use of iridium is certainly novel.

Drying Iron Ore on the Mesabe Range.

Some of the iron ores mined on the Mesabe range in Minnesota contain so much moisture that its elimination prior to shipment is a matter of economic importance. Some minor efforts have been made heretofore along this line, but not until the M. A. Hanna Company erected a large drying plant for the Brunt mine, at Mountain Iron, Minn., was any attempt made to dry a large tonnage of iron ore.

Several essential points in such a plant immediately suggest themselves. The system must have a large capacity; the physical condition of the ore must not be impaired for use in the blast furnace, and the expense of the drying operation should not exceed, at most, the cost of freight on the moisture in the wet ore.

When completed, the drying plant of the M. A. Hanna Company will have a capacity of 3000 tons per day. The plant provides for five Atlas dryers, each of 40 tons capacity per hour; but as the entire plant will not be continuously in operation, it is estimated that a capacity of only 3000 tons per day will be maintained steadily.

The wet ore contains from 16 to 18 per cent moisture, and the dried product about 3 per cent. The ore is first thrown onto grizzly, 4½-in. spaces, the oversize from which is crushed in a gyratory crusher and returned to the grizzly. This system secures a thorough mixture of the lump ore with the fine, which is wetter, and avoids sending large compact masses of wet fine ore to the dryers. From the bin beneath the grizzly the ore is carried by belt conveyors to the dryers, which are of the revolving cylinder type, made by the Atlas Dryer Company, Cleveland, Ohio.

The drying cylinder is designed so that a large volume of dry hot air may be drawn through openings in the cylindrical wall and come in contact with the wet ore. The cylinder may be likened to a large trommel screen, with the openings so guarded on the inside that no ore can fall out during its passage from the feed inlet to its point of discharge at the other end of the cylinder.

In Fig. 1 is shown the cylinder in place, surrounded by a steel casing like a boiler setting, with adjacent firebox to provide heat, and exhaust fan to induce a draft of heated air

FIG. 2.—DRYING CYLINDER SHOWING AIR INLETS.

through the cylinder. Openings G in the casing provide for the admission of air, which being heated by the fire, passes into the cylinder in contact with the ore. At the Hanna plant the fan draws 28,000 cu. ft. of air per minute through the cylinder. The temperature of the air entering the casing is about 60 deg. Fahr., while that of the air passing out through the vapor bonnet is approximately the boiling point of water. Eight pounds of water is evaporated per pound of fuel burned.

The relation of the firebox to the casing and cylinder is such that the hottest air is drawn into the cylinder at the feed end where the ore is wettest. The temperature of the air entering the cylinder diminishes toward the discharge end, as does the moisture content of the ore. Likewise the suction of the fan is greatest at the point where the ore is wettest and the air hottest, diminishing toward the discharge end of the cylinder

where the moisture in the ore and the temperature of the air are greatly reduced. In this way the volume and temperature of the air are proportioned to the moisture to be removed.

The drying cylinder is shown in Fig. 2, the horizontal rows of air-inlets being shown on its central portion. Fig. 3 gives an enlarged view of one of the air-inlet castings which are
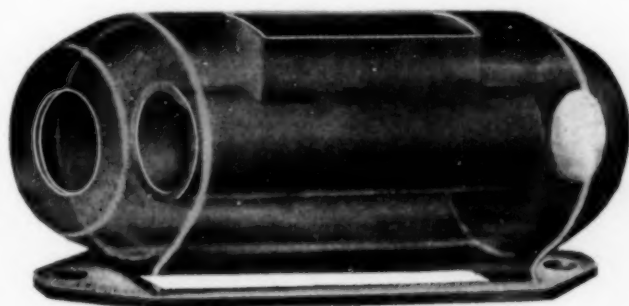

FIG. 3.—AIR-INLET CASTING.

attached to the cylinder. By reference to Fig. 4 the reader will observe the position of the castings on a section of the cylinder, also the means for preventing the ore from falling through the air-inlets. The castings are placed in recesses in the cylinder wall, and within the cylinder are metallic blades guarding

FIG. 4.—CROSS SECTION OF DRYING CYLINDER.

the air openings. These blades serve also to raise the ore and allow it to fall through the heated air during its passage through the cylinder.

The drying of iron ore in commercial tonnages is still a new industry on the Missabe range, but with the introduction of successful drying apparatus it may become more extensive.

Natural Gas.

According to the U. S. Geological Survey, the quantity of natural gas produced in the United States was practically the same as in 1910, while the value increased from $70,756,158 to $74,127,534, a gain in value of 4.76 per cent. The conditions of production were particularly interesting in Ohio, which as a consumer of gas in 1911 takes second place, having consumed 112,123,029,000 cubic feet, valued at $22,792,270. The total quantity of gas produced in this State was 49,449,749,000 cubic feet valued at $9,367,347, compared with 48,232,406,000 cubic feet, valued at $8,626,954, in 1910. The difference between the gas produced and that consumed in Ohio shows the quantity piped into the State from West Virginia and Pennsylvania.

Notes on Chemistry and Metallurgy in Great Britain.

(From our London Correspondent.)

The Iron and Steel Institute.

The autumn meeting of the Iron and Steel Institute was held at Leeds in the Hall of the Philosophical and Literary Society and extended from Sept. 30 to Oct. 4.

Two papers by Sir Robert Hadfield on "A Method of Producing Sound Ingots" and "On a New Method of Revealing Segregation in Steel Ingots," and a paper by Dr. Hans Goldschmidt (of Essen) on "A New Method for the Improvement of the Soundness of Steel Ingots by the Aid of Thermit," were discussed together. Sir Robert Hadfield advocates keeping the top of the ingot hot by the combustion of charcoal with a supply of compressed air blown on to it, placing a layer of cupola slag between the top of the ingot and the charcoal to prevent injurious action and loss of heat by radiation. Dr. Goldschmidt plunges a charge of thermit right down to the bottom of the ingot while this is still in a fluid condition, and, after ebulition, due to violent expansion of gas, has ceased the metal in the mold sinks down and more metal is added from the ladle. Only a small charge of thermit is necessary; about 1 lb. being sufficient for a ton ingot. (Both papers were published in our November issue.)

The discussion was opened by Sir Robert Hadfield, who said that the experience of the past winter in the United States had caused a demand there for a better quality of iron for rail making. He might possibly be wrong in his ideas as to piping and segregation, but he thought it possible to take a block of fluid steel and have no piping at all. If there were no piping there would be no segregation. He had tested this by making a small ingot, 2 ft. 6 in. in length, and keeping the top hot as long as possible. A sulphur print of the metal showed almost entire freedom from segregation, and he believed the same results could be obtained with larger ingots similarly treated. Piping was practically absent in that ingot, which, if made in the ordinary way, would probably have piped considerably.

The president said the subject was most important to steel makers, who were all trying to get the maximum quantity of sound metal from the ingot.

Dr. J. E. Stead agreed that the papers were interesting and valuable, while the authors appeared to have worked on opposite principles, one keeping the top hot and the other the bottom. He thought that the proper principle to work on was to keep the top hot; and really in Dr. Goldschmidt's process the hot metal from the bottom came to the top, and it was equivalent to heating the top. He thought the principle of heating the bottom was wrong, and he would prefer a refrigerator at the bottom and a blast at the top. He suggested that Dr. Goldschmidt should place the thermit nearer the top, and he thought he would thus obtain still better results than the remarkable ones quoted in the paper. They were much indebted to Dr. Goldschmidt for his researches, but he would probably obtain still better results from some slight modification of his process. The accumulated evidence of the last few years proved that in ingots of non-gaseous steel—unless poured very slowly or into molds wide end at the top—the steel remained fluid longer in the lower central axis than in the upper. He submitted a photograph of an etched rail section the central axis of which consisted of almost pure iron. The present explanation of the great purity of the central axis was that the ingot was rolled before the center was quite solid and consisted of crystallites of nearly pure iron mixed with a liquid containing greater part of the metalloids. On passing through the rolls this liquid would be squeezed up into the pipe, leaving behind the solid nearly pure iron. If there was no cavity the liquid might be expelled at the top if the solid metal there were thin, and if it were too thick expansion might ensue at the thin end.

In March of the present year Karl Neu had demonstrated

that rolling ingots before the centers were solid produce blooms with the central axis practically free from metalloids. If Sir Robert's copper method were applied to such an ingot the copper would descend, displacing the impure residual liquid, and, when cold, would be found in the lower central axis, and—according to Sir Robert—would indicate normally unsoundness there, whereas normally that would be the soundest part. That method could be useful only when the steel had quite solidified.

At Cargo Fleet Works Mr. Benjamin Talbot had, during the past two years, experimented on and successfully worked out a process of producing sound ingots. He attains soundness, except as to the central pipe, by means of aluminium or silicon. The ingot is quickly stripped, allowed to stand in the soaking-pit for a short time, and then, with its center still liquid, compressed by a few passes through the cogging mill. Ingots so produced have been found uniformly free from unsoundness, and the parts richest in sulphur, phosphorus and carbon were located in the positions where it was most desirable that anything objectionable should be.

Mr. Benjamin Talbot said he had found it possible to produce rails with a hard face and soft center.

Mr. J. M. Gledhill, of Messrs. Armstrong, Whitworth & Company, remarked that Mr. Talbot's interesting work suggested that the compression system of treating segregation, which they had adopted at their works for large ingots, was the right one. They had recently dealt with a 128-ton ingot, employing a hydraulic pressure of 1200 tons, and except for a little segregation at the bottom the material was entirely homogeneous, and that meant a yield of at least 100 tons of sound metal.

Mr. G. Baker asked what the result of Sir Robert Hadfield's process would be with bottom pouring, which produced a solid crust of steel on which the slag and its covering of charcoal would be placed, and which, one would think, it would be requisite to melt.

Mr. A. S. Keith (Leeds Steel Works) said his firm was making principally tramway rails, of which their output during the last sixteen or eighteen years amounted to 150,000 to 200,-000 tons, but for seven or eight years they had been supplying to some of the leading British lines permanent-way rails made from Bessemer basic steel which appeared to give as much satisfaction as other kinds of modern rails. Complaints of broken or defective rails were very rare, although he admitted that his firm's practice was not the most recent. He thought that the use of the processes under discussion would affect the output in small works, and while they continued to supply a rail giving good results and secured repeat orders their practice must be at all events equal to that of more modern works.

Mr. W. H. Hatfield said that Sir Robert Hadfield's methods seemed to satisfy practically all requirements for the production of sound ingots; and his objection was removed by the fact that a sample taken 3½ in. below the surface was virtually of the same carbon content as the ingot. Was there any pulling in these ingots? The disadvantage of Dr. Goldschmidt's process was that after introduction of aluminium by the thermit and formation of a pipe he poured more steel into the ingot. This was a tedious process.

Mr. H. Brearley, with regard to Mr. Baker's question as to the effect of bottom pouring, pointed out that in Sir Robert's process the metal was hottest at the top and consequently in better condition for feeding down than a bottom-cast ingot would be with its cold metal at the top. Sir Robert had embodied and improved two distinct operations which had been in use for a long time in making tool steel, one of which was casting wide end up and the other was the use of charcoal on top of the ingot—a practice of long standing in the production of crucible steel, but without a layer of slag. He was unable to agree with the statement that if there were no piping there would be no segregation, for he had seen perfectly sound ingots of 2 cwt. or 3 cwt. which inevitably showed segregation

when polished and etched. He asked whether Dr. Goldschmidt's process introduced a considerable quantity of slag into the ingot.

Dr. Stead produced for inspection photographs supplied by Mr. Talbot to show the necessity for inert material between the charcoal and the top of the ingot. These photographs demonstrated that without such interposition the oxide caused by the blast penetrated even to the bottom of the ingot.

Sir Robert Hadfield in his reply said his view was that cooling should go on from the bottom. Dr. Stead's communication with regard to Mr. Talbot's results was of very great interest, but it was advisable that definite information should be furnished to show the yield of merchantable steel. With regard to the use of aluminium and silicon, they were harmless; then why not use them if sound piping resulted? Twenty-five years ago in a paper before the Institute he showed that a material of very fair ductility could be produced with 1 per cent of silicon, and when 0.2 or 0.3 per cent would insure soundness there need be no fear of using it. With regard to Mr. Baker's practical question as to the crust on the top of a bottom-poured ingot, the heat developed by the combustion of the charcoal would readily melt any half-crusted steel. As to pulling, after the practical production in this way of many thousands of tons of ingots he had not known of more than one or two pulling at the top on account of flash. The amount of heat lost by radiation was small, and the supply of heat at the top not only prevented radiation there but maintained the heat where it was wanted. He was glad that Dr. Stead agreed with his point of feeding from the top rather than adopting means to secure soundness at the bottom. With regard to the time taken for this feeding, the quantity of air used and the charcoal, the extra cost of the process did not exceed 1 shilling per ton. Ordinary cupola blast, at a few ounces pressure, was used.

Dr. Goldschmidt replied that he was sorry that he could not accept Dr. Stead's proposal to use the thermit near the top of the ingot, for he had tried that method many times in many works, and the results were not successful. Dr. Stead had said that he heated the ingot at the bottom, but that was not the case. The rise of temperature resulting from the thermit was not more than 1 deg. C.—practically nothing. He did not regard the reaction in the liquid ingot as thermal, but as mechanical with ebullition which drove all impurities to the top. There was not necessarily any inconvenience in filling up the ingot after the reaction, and two works had adopted the plan of pouring in liquid steel immediately after the reaction and then covering the ingot, but this entailed the loss of a few inches of the ingot. As to the introduction of slag into the ingot, he had given figures in the paper relating to some 20,000 ingots and no slag was found in the metal.

The Royal Mint.

From the forty-second annual report of the Deputy Master it appears that in the year 1911 the total number of pieces struck exceeded 146,000,000: the gold issue was of the value of more than £33,000,000, or rather greater than 2.5 times the average of the previous ten years, and £8,000,000 greater than the issue of any preceding year. The cost of coal gas fuel for melting gold bullion worked out at 5.2d. per cwt.

In the new gold melting house there are ten furnaces. The gas is supplied by a 4-in. main, the air by a 5-in. pipe, and the blower is driven by a 14-hp motor. The silver house has sixteen furnaces suitable for 8000-oz. crucibles capable of dealing with 9.6 tons of standard silver per day, but at present the crucibles are of the 6000-oz. size. An ordinary day's melt in the gold house is 3 tons of standard bullion.

The old atmospheric engine for operating the automatic weighing machines has been replaced by an electric motor. The total number of motors installed is now eighty-nine, with an aggregate of 786 hp. The net profit on the year's working was £374,266.

Cleveland Meeting of the American Institute of Mining Engineers

The 103rd meeting of the American Institute of Mining Engineers was held in Cleveland, Ohio, from Monday to Thursday, October 28 to 31, 1912, and proved to be one of the most enjoyable and successful meetings of the Institute in recent years.

It was the first meeting held under the auspices of the newly formed Iron and Steel Section of the Institute and accordingly the metallurgy of iron and steel was particularly well represented on the program. For the same reason Cleveland, as the center of the Lake Superior iron industry, had been chosen for the meeting, this being the third meeting of the Institute in that city, previous meetings having been held there in 1875 and 1891.

On Monday evening the visiting members and guests were informally entertained at the headquarters in the newly opened Hotel Statler by the local committee, with Mr. D. T. Croxton as chairman and Mr. C. B. Murray as secretary.

On Tuesday morning the professional sessions started, all the sessions of Tuesday and Wednesday being held in the Assembly Room of the Hotel Statler.

The Tuesday morning session was opened by addresses of welcome by Mr. David T. Croxton, president of the Cleveland Furnace Company, and Mayor Newton D. Baker, of Cleveland, who compared in a felicitous little speech some future possibilities of development in the professions of mining engineers and of politicians. A graceful reply was made by the president of Institute, Professor James F. Kemp.

Rail Steel Inspection and Manufacture.

The first paper was read by Colonel **Robert W. Hunt,** of Chicago, on "Recent Developments in the Inspection of Steel Rails," describing the new system adopted by thirty-three railroad companies operating more than 122,000 miles track. Inspectors are placed by the railroads in each manufacturing department of the steel company making the rails, to be on duty during all working hours. These inspectors have to observe all manufacturing operations and if there are serious variations from the details of specifications or from recognized good practice, they have to call the attention of the foremen to what is going on, make a record of the fact, and report it to the inspector in the next department to which the ingot, bloom or rail is passing in the progress of manufacture. The details of the inspectors' observations are also to be reported to the railway company that purchases the rails. This plan of inspection has been cheerfully accepted almost universally by the steel rail manufacturers.

This paper elicited an extended discussion which had as much to do with rail steel manufacture as inspection. Mr. H. D. Hibbard asked about the discard. Captain Hunt replied that there was no uniform practice. The specifications made by the different railway companies are different. While the usual amount of discount is 9 per cent, some railway companies specify that the shearing of the bloom be continued until soundness is assured. In those few cases in which 20 to 25 per cent discard is specified a special charge is made.

In reply to the question of Mr. Charles Kirchhoff whether the manufacturers still give a guarantee of five years Captain Hunt replied in the negative.

In reply to a further question by Mr. Hibbard as to who determines the amount of discard, whether the rail makers or the inspectors of the railway companies, Captain Hunt said that that was a point which was perhaps as much disputed as any other point. It referred to a delicate situation. If the in-

spector of the railway company would assume the right to say what should be the discard, he would also have the responsibility and the manufacturer would be relieved of responsibility. This is not exactly what the railway companies want. Their inspectors should rather report at once, whenever, in their opinion, any discard has not been sufficient. This goes into the record, and if a rail of that ingot breaks later on they know the reason why.

Mr. Fred Laist asked about the addition of copper to steel rails for the purpose of toughness. Captain Hunt replied that for the Chicago, Milwaukee & St. Paul Railway 10,000 tons of rails of steel containing 0.5 per cent copper had been made by the Illinois Steel Company. The rolling results were quite satisfactory. The copper had been added in the form of copper wire in the casting ladle. This order had been the outcome of very satisfactory results obtained with rails made from ore which contained copper.

Mr. Elwood Haynes, president of the Haynes Automobile Company, said that the chemical process of making the steel was fully as important as the mechanical treatment; for instance, introduction of titanium was just as important as the proper procedure in rolling. For automobile manufacturers the use of nickel and vanadium in steel was very important on account of the ability of such steel to stand vibrations and shocks very well.

Captain Hunt explained that the inspection covers the metallurgical side of steel making as well as the mechanical processes. It is a complete inspection of the metal from the time it is tapped from the furnace until the product is finished. It includes, for instance, additions of various ferroalloys, the condition of the ingot molds, etc., in short the whole history.

Titanium Treatment of Cast Iron.

A paper by **Mr. Bradley Stoughton,** of New York City, gave "Notes on Titanium and on the Cleansing Effect of Titanium on Cast Iron." The paper gives the results, first, of a research into the somewhat extensive literature on titanium, and, second, on a series of original tests extending over a period of more than two years upon the effect of titanium on iron castings. The combined results are summarized as follows:

"1. Steel or cast iron, in which the titanium is properly proportioned, and which has been properly treated, is improved in strength, toughness, and durability against wear, such as, for example, the wear of railroad-rails, of steel and chilled-iron rolls, car-wheels, etc.

"2. These improvements seem to be caused, not so much by the direct effect of titanium on the metal, as by its cleansing influence in removing harmful impurities, such as oxygen and oxides, nitrogen, occluded slags, and perhaps also sulphur. It appears also to reduce segregation, which would contribute to the same end.

"3. In order that its effects may be fully realized, the treatment of steel or iron with titanium must be correctly performed. There are a few simple but essential details to be observed; if they are neglected the best results cannot be expected.

"To illustrate by an example: A series of tests on cast iron was carried on in a German foundry, in which scientific apparatus and instruments were employed, and great care apparently exercised in executing the work, but the titanium treatment was performed without a knowledge of the conditions which should have prevailed, and, as a consequence, the

results were inconclusive. It is as if one should attempt to boil water with the best adapted appliances obtainable; with scientific instruments to measure the temperature and regulate the operations, and with every condition fulfilled except heating the water to a high enough temperature. Obviously, the result would be quite as unsatisfactory at 211 deg. F., as far as boiling water is concerned, as at 60 deg., although the former point it within a hair's breadth of success. So, in adding titanium to iron or steel, if it is put into the slag, instead of the metal, or if opportunity is not given for it to be absorbed and do its work, or if the steel is subsequently allowed to become oxidized, or if the treated metal is cast much too hot or much too cold—if any, or all, of these important details are neglected, we must not expect to get the best results."

From a summary of the results obtained by different investigations the author concludes "that it is entirely possible, by correct treatment with ferrotitanium alloy, to increase the strength of cast iron from 30 to 50 per cent. If this can be done part of the time, then it only remains to determine the correct conditions in order to attain equal success all the time. Some of these conditions I have pointed out, but I do not consider that the problem is completely solved as yet."

In the discussion which followed, Mr. J. E. Johnson, Jr., asked whether titanium reduces the chill. For many purposes in foundry practice the proper chill is important, for instance, for the manufacture of car-wheels and rolls. If titanium reduces the chill it will not be good for such purposes.

Mr. Stoughton replied that if titanium would be used under otherwise unchanged conditions it would reduce the chill. Against this stands the fact that for about 90 per cent of all the rolls and also a good many car-wheels now being made the titanium treatment is employed. But to achieve success it is necessary to change the silicon and manganese contents in order to get the required chill with the titanium treatment. An increase of manganese is necessary. Details of the treatment are kept secret to a certain extent.

President Kemp gave a review of the existence of numerous deposits of titaneferous iron ores, which, if made available, would add very greatly to our iron ore supply. Many of these also contain vanadium and chromium.

Cuyuna Iron Ore Range.

Two papers supplementing each other, by Mr. **Walter Barrows**, Jr., of Duluth, Minn., and Mr. **Carl Zapffe**, of Brainerd, Minn., discussed "The Iron Ores of the South Range of the Cuyuna District of Minnesota." In the discussion Mr. D. T. Croxton referred to the successful use of these ores in mixtures of 40 to 60 per cent and even as high as 90 per cent by the Cleveland Furnace Company.

* * *

Case Hardening.

Two papers relating to case hardening were then presented. One discussed the "action of various commercial carbonizing materials," the author being Mr. **Robert R. Abbott**, metallurgical engineer of the Peerless Motor Car Company, and the other paper dealt with "measurements and relations of hardness and depth of carbonization in case-hardened steel," the author being Mr. **Mark A. Ammon**.

Mr. Abbott gave the results of extended tests made with twenty-five different commercial case-hardening compounds. They include pure bone, bone in which the glue has been partly or wholly extracted, bone mixed with other carbonaceous material, partly roasted nuts, husks and kernels of seeds or beans, and finally charred carbonaceous material charged with chemicals. These different materials are designated in the paper by letters from A to Y and the names of the compounds or of the manufacturers are not given. The results of the extended tests are given in numerous tables and diagrams and it is impossible to abstract them.

It is also shown in the paper how to apply the results given in the tables and diagrams for practical purposes. The use to which case-hardened steel is to be put should be the deciding factor in selecting the material with which it is to be carbonized, and also to a less extent the temperature of carbonization should be determined from similar considerations.

The paper by Mr. Ammon on measurements and relations of hardness and depth of carbonization in case-hardened steel points out that the two most widely used methods of measuring hardness are the Brinnell method and the scleroscope.

In the Brinnell method a hardened steel ball is pressed into the steel under a definite load and the area of the resulting depression is measured. In the scleroscope method a small weight carrying a diamond point is dropped through a glass tube upon the steel and the amount of rebound is taken as proportional to the hardness.

When applied to case-hardened steel both methods should not be expected to give the same results because the scleroscope method gives almost exclusively the surface-hardness, and the condition of the material below the surface has but a slight bearing upon the hardness number. The results given by the Brinnell method should, however, be the exact opposite; for the depth of penetration of a ball pressed into the steel would be dependent to a large extent upon the condition of the material below the surface.

The author has made an investigation into the hardness of case-hardened steel by means of a combination of these two methods. The results of the investigation are given in a series of tables and twelve diagrams and certain facts shown in these results are summarized. The knowledge gained by this research work has formed the basis of a system of testing carbonized parts for depth of carbonization and efficiency of the heat treatment.

The two papers were discussed by Messrs. Hibbard, Johnson, and Stoughton. A unanimous vote of thanks was passed to the automobile companies for their liberal policy in permitting the publication of the information contained in the two papers.

* * *

Ruff's and Wittorff's Carbon Iron Equilibrium Diagrams.

A paper by Professor **Henry M. Howe**, of Columbia University, points out that "Prof. Ruff's most illuminating paper describing his extremely valuable investigation of the carbon-iron equilibrium diagram assigns definite temperatures to certain very important lines in the diagram," viz.: the eutectic temperature and the "near eutectic" temperature, but without indicating clearly enough the reasoning which warrants these assignments. Prof. Howe, in his present paper, indicates the apparent gaps in the reasoning.

He concludes that the unexplained variations in the cooling curves are very great, that the two series of observations on this point by Gutowsky do not agree; and that the rate of graphitization is very capricious. Graphitization continues at temperatures far below those to which Prof. Ruff seems to confine it. There is difficulty in reconciling the Gutowsky and the Ruer and Iljin lines with the assumed dominance of the "bodenkoerper," all of which seem essential premises underlying Prof. Ruff's reasoning. "In view of these facts the data as to arrest temperature and graphitization in the single Gutowsky series used by Prof. Ruff seem wholly insufficient for a firm foundation on which to base calculations as to the equilibrium position of the eutectic temperature."

Mr. **Bradley Stoughton** then presented a translation in abstract, prepared by him with the aid of Mr. Sidney Marcus from the Russian original of N. M. Wittorff's "Preliminary Investigation of Primary Crystallization and Subsequent Physico-Chemical Permutations in Iron-Carbon Alloys Containing More Than 4 per cent Carbon." Mr. Stoughton showed that this paper is of great interest in connection with Howe's paper.

The result of Wittorff's study is to greatly extend our knowledge of the hypereutectic alloys of iron and carbon, and to add several significant lines at the right-hand side of the diagram originally drawn by Bakhuis-Roozeboom, and developed by Roberts-Austen, Benedicks, Carpenter & Keeling, Upton, Goerens, and others.

The two papers of Professor Howe and Mr. Stoughton were discussed at some length by Messrs. J. E. Johnson, Jr., Henry D. Hibbard, Bradley Stoughton, R. H. Sweetser, and James F. Kemp, and it is particularly noteworthy to record that such distinguished blast furnace men as Messrs. Johnson and Sweetser emphasized the value of equilibrium diagrams for practical furnace operation. This concluded the meeting of the morning.

The afternoon session was also held in the Statler Hotel and the first paper was presented by Mr. Sweetser.

* * *

Blowing in a Blast Furnace.

The object of this paper by Mr. **R. H. Sweetser,** of Columbus, O., is to put on record a blowing-in practice that has gradually developed to the point where the results are sure, safe, and satisfactory; and also to bring into discussion several variations that are questionable.

"*Drying-Out the Furnace.*—As soon as a furnace-lining is completed it should be thoroughly dried out, whether it is to be blown-in soon or not; and the longer it is dried, the better for the furnace. At least two weeks is desirable; but good results can be had with 10 days of firing. The crudest and least desirable method of drying is to build a wood fire in the bottom of the furnace, throwing the wood in through a tuyere-arch, and using the iron-notch for draft. The accumulation of wood-ashes on the hearth-bottom keps the brick from heating thoroughly, and considerable time is lost in removing the ashes.

"An effective and easily-controlled method is to build a 'Dutch oven' outside one of the tuyeres and use coke for fuel. This method may be intermittent or continuous, a desirable feature, since sometimes it is necessary to pack plates or coolers on the day-turn, and dry-out on night-turn. Coal could be used for fuel, but coke is cleaner and gives a hotter fire.

"The 'Dutch oven' can be built at the iron-notch, but often it is necessary to fit up the iron-notch gun and the gun-bar; and then the oven would be in the way. With the oven at a tuyere-arch, the hearth-bottom can be well heated by a wood fire built right in the casting-trough; the strong draft will draw the heat through the iron-notch. Fig. 1 shows a simple oven for a tuyere-arch; if used at the iron notch, the neck of the flue would have to be turned downward.

"*Pipe for the Iron-Notch.*—In order to burn completely all the kindling wood below the tuyeres before the slag falls into it, and also in order to heat up the hearth-bottom thoroughly, it has long been customary to place an iron pipe, 3 or 4 in. in diameter and about 10 ft. long, in the iron-notch. This pipe should project from 6 to 18 in. inside the furnace wall. If the hearth bottom is much below the level of the iron-notch there is no need for the pipe to project much beyond the inside of the walls, but if the hearth level is almost up to the bottom of the iron-notch, the pipe should project farther. In either case the part of the pipe inside the furnace should be thoroughly covered over with stiff clay, so as to protect it from any molten slag or iron.

"The pipe should be in the center of the iron-notch, and as nearly level as possible. Near the outer end of pipe there are four holes, 0.75 in. in diameter, in which to insert hooks for pulling out the pipe when the time comes. As soon as the blast is on the furnace, the gas will come through the pipe out into the iron trough, where there should be a wood fire to ignite it immediately. As the volume of gas increases, the gas flame at the end of the pipe gets hotter and roars more, but

does no harm. It is my practice to let this gas burn at the iron-notch for four hours after starting the blast, and then to pull the pipe and shut the notch.

"Shutting the iron-notch is one of the critical stages of blowing-in; but if everything is in readiness the work can be done in less than three minutes, with an iron-notch gun and a steam cylinder attachment on the gun bar. The iron pipe should be turned in the iron-notch so as to loosen the clay; this can be done by inserting a bar or hook in one of the four holes near the outer end of the pipe. A quick jerk on the hook will pull the pipe clear of the iron-notch, and then the gun is swung around quickly and forced into place with the steam cylinder.

"*Filling the Wood.*—The placing of the kindling wood in the hearth and bosh is such an important part of blowing-in a blast furnace that the superintendent or his assistant usually gives
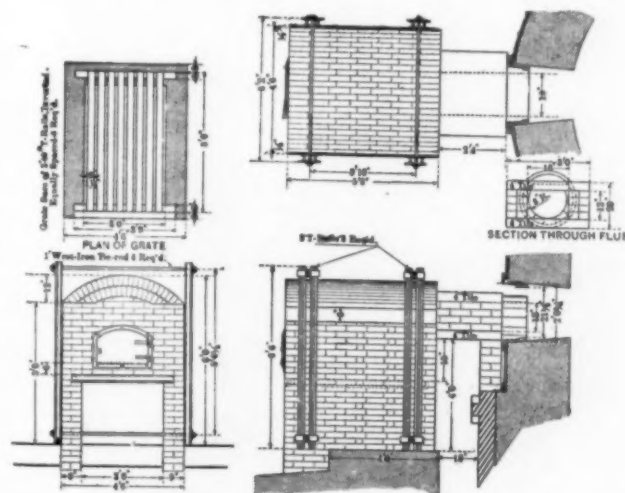

FIG. 1.—"DUTCH OVEN" FOR DRYING OUT BLAST FURNACES.

personal attention to each detail, staying inside the furnace to see that every stick of wood is properly placed. The simplest method (as is often the case in furnace practice) of putting wood in the hearth has proved to be the best in every way. David Baker taught it to me twenty years ago, and he doubtless learned it from some old furnace man at Steelton. No fancy scaffold is made, but cord sticks are packed as tightly as possible, in alternate layers at right angles to each other, from the hearth bottom up to the level of the bottom side of the tuyeres. The wood is all passed into the furnace through one tuyere-arch with the cooler left out.

"At the Algoma Steel Company I first used the 'Algoma cones' at the tuyeres. These are made by placing dry building laths in front of each tuyere with the inside ends coming to a point towards the center of the furnace, and the other ends placed all around the nose of the tuyere. The spaces between cones are filled up with short sticks, split cord sticks, and any dry kindling available, and the whole surface is leveled with the exception of a place about 3.5 by 4 ft. in front of the tuyere where the wood is passed in. A vertical shaft about 10 ft. high is here made by nailing four posts (4-in. x 4-in. sticks or small saplings) in position. Two posts will be close to the wall on either side of the tuyere-arch and the other two will stand about 4 ft. from the wall. Cord sticks are then piled on end all across the furnace and around the shaft; then a second tier of cord sticks is placed in as tightly as possible. Usually the top of this second tier will be below the top of the bosh, and cord sticks are laid against the walls all around the furnace to protect the brick and plates from falling stock.

"When this is done enough wood is passed inside the furnace and up the shaft so that when the last man 'backs out' he can fill the shaft solid with wood. All the men except two go

outside, and the tuyere cooler is set in place. The two men pack the cooler from inside with clay, and place the kindlings in front of the tuyere, then 'back out' up the shaft. The wood is then thrown down into the shaft and packed in solid, and the two men are hoisted out at the top of the furnace in a boatswain's chair.

"Filling with wood in the above manner accomplishes perfectly three things desired, namely: the heating-up of the hearth without leaving any appreciable amount of ash; the ignition of the coke charge and the starting of the smelting process; and the movement of the stock with such gentleness that the settling on top, within two hours after the blast goes on, cannot be detected except by using the gage rod.

"Coke on the hearth bottom and built-up scaffolds do not usually attain all these points, and do not produce good iron on the first cast.

"*Filling the Stock.*—On top of the wood, regular charges of coke with just enough limestone in each charge to flux the ash of the coke, are dumped in the usual manner. The size of this coke 'blank' is more often too large than too small. I am indebted to Frank P. Howe, of Philadelphia, for learning the advantages of using about 20 tons of coke instead of 40 or more. The next set of charges has an equal amount of coke plus cupola slag and enough limestone to flux the coke and slag. Then follow the ore charges with gradually decreasing amounts of slag. Charcoal furnace slag is excellent for the slag charges, but is usually harder to get than clean cupola slag. If the slag is not granulated it should be broken up to about 2-in. size. A good volume of easily melted slag is needed to fill up the hearth and receive the first iron that comes down.

"A charging schedule that has worked successfully several times is as follows:

Charges.	Coke. Pounds.	Limestone. Pounds.	Cupola Slag. Pounds.	Ore. Pounds.
6	6510	730	0	0
6	6510	4000	4000	0
5	6510	4300	4000	1800
5	6510	3600	3000	2400
5	6510	3000	2000	3600
5	6510	3300	2000	5000

"These materials filled a 75-ft. x 18-ft. furnace.

"The first five charges after the blast went on had 1000 lb. of slag and 6400 lb. of ore; then the slag was omitted and the ore gradually increased to full burden.

"When the stock gets within about 20 ft. of the top, it is a good plan to take measurements of the surface of the stock, and to make careful observations of the distribution; at this time gage rods should be tested as to accuracy in reading.

"*Putting the Blast On.*—I believe in putting the blast on at once, and using hot blast to light the furnace whenever previously heated stoves are available. If the volume of blast is increased properly the furnace will not 'hesitate,' but will move off easily, and the first slip will be indefinitely postponed. If the stoves have not been previously heated with gas, then redhot rods are thrust in through the tuyeres to light the kindlings.

"If the furnace is a single stack and the gas flues are cold and empty, the method of 'bringing down the gas' is different from the way when there are one or more furnaces in blast and delivering gas into the same gas mains.

"When the blast is turned on a single stack, both bells and the top bleeders are left open for a while and not closed until there is a steady and voluminous flow of gas at the top of the furnace. The big bell, and then the little bell, are closed, and all the gas goes out at the bleeders. All gas burners on stoves and boilers are tightly closed, and all fire is kept away from dust catchers and cleaning doors. The gas mains are gradually filled with the dense white furnace gas by partly closing the bleeders. At the farthest end of the gas main, gas is allowed to escape through a valve or a cleaning door, so as to expel all the air in the mains. When gas is leaking through all the

cracks of doors and burners, and there is pressure inside the gas main, the last gas burner under the farthest boiler is slowly opened, and the gas is lighted by the fire on the boiler grate. The bleeders are then closed so as to force all the gas into the mains. By having the mains full of gas at a pressure of a few inches of water, the danger of explosions is averted. The very dangerous quality of the blowing-in gas is shown by the analyses I made and recorded in the *Transactions* of the American Institute of Mining Engineers, Vol. 28, page 608 (1898), but all trouble can be avoided by proper handling of the gas. Great care must be taken not to open gas burners faster than the volume of gas will allow, as the volume and pressure increase, the burners at the stoves can be opened.

"In the cases of 'twin' furnaces all these precautions can be omitted and the gas from the new furnace can be soon turned into the gas mains by closing the bells and bleeders. Of course, the gas valve between the new furnace and those already in blast must be opened just before the blast is turned on.

"I will not attempt to give in exact cubic feet the amount of blast that should be blown during the first hours of blowing-in; but the volume at all times during the first day or two should be sufficient to prevent must blast pressure on account of 'hesitating' in the settling of stock. While the wood is burning the blast-volume should be sufficient to prevent gas from coming back in the tuyeres by reason of the pulsations of the engines. I usually start with 25 per cent of the normal blast.

"*The First Flush and First Cast.*—The first flush is anxiously looked for in ten or twelve hours after the blast goes on. Where slag is used in filling the furnace, a considerable amount should be flushed out before any attempt is made to open the iron-notch.

"In opening the iron-notch for the first time there should be no trouble whatever, providing the keeper drills in on the level and through the soft clay that fills the hole left by the 4-in. pipe. Sometimes a big tapping bar is driven into the soft clay as soon as the iron-notch is shut for the first time, as described above. But I have found that there are several disadvantages in this and now prefer to leave the bar out.

"The furnace blown in Aug. 17, 1909, had very hot stoves to start with, and the blast-temperature exceeded 1400 deg. On this account the blast-volume was increased more rapidly than usual, and the first cast (34,620 lb.) was only thirteen hours after the blast went on.

"The furnace blown in Aug. 20, 1912, had no bottom brick on top of the salamander that had been left in, and on account of the increased depth of hearth the cinder was longer than usual in filling up the cinder notch."

SOME RECORDS WITH THE "COLUMBUS METHOD."

Date.	July 15, 1908.	Aug. 17, 1909.	May 21, 1912.	Aug. 20, 1912.
Size of furnace, feet	75 by 18	75 by 17	75 by 18	75 by 18
	Single.	"Twin"	Single	"Twin"
Blast on	8:03 A.M.	8:25 A.M.	4:03 A.M.	3:42 P.M.
How lighted	Hot rods	Hot blast	Hot blast	Hot blast
Stock settled	9:45 A.M.	9:20 A.M.	6:10 A.M.	5:20 P.M.
Iron-notch shut	....	11.05	8.00	8.22
	12:35 P.M.	11:11 A.M.	8:05 A.M.	8:25 P.M.
First flush	6:45 P.M.	6:37 P.M.	4:20 P.M.	8:00 P.M.
First cast	10:10 P.M.	9:25 P.M.	7:30 P.M.	12:30 P.M.
Silicon, per cent	4.33	2.73	3.53	1.79
Sulphur, per cent	0.044	0.028	0.017	0.035
Tons pig first week	1,302	1,137	1,410	1,263

In the discussion which followed Mr. Johnson referred to the danger of explosions in bringing down the gas. Mr. Dougherty had taken out a patent for overcoming this difficulty by inserting a cushion of steam in the downcome to prevent the dangerous mixture of gas and air. But this had been used years before the patent was taken out, so that anybody may use it.

* * *

Cobalt-Chromium Alloys.

A paper by Mr. **Elwood Haynes**, president of the Haynes Automobile Company, of Kokomo, Ind., gives the results of his very interesting researches on the properties of alloys of cobalt with chromium and other metals.

The preliminary fusions were made in graphite crucibles by means of a furnace operated by natural gas, and later in crucibles of a special composition, not only to avoid the contamination of the metal by carbon from the crucible, but also because they proved more reliable under long-continued heating.

"The metal tungsten alloys readily with chomium and cobalt in all proportions. When added in small quantities to the cobalt-chromium alloy, it seems to have little influence on the properties of the combination but if the proportion rises to 2 or 3 per cent a notable effect is produced. Generally speaking, the cobalt-chromium alloy becomes harder and more elastic, especially if it contains a small amount of carbon, boron, or silicon.

"The following experiment shows the effect of melting the alloy in a graphite crucible: 90 g. of cobalt, 6.3 g. of tungsten, 18 g. of chromium, together with a small quantity of calcium silicide, were introduced into a graphite crucible. The resulting alloy was very hard, and the crucible much eroded on the inside. The bar could be slightly flattened at one end, and after being made into a cold-chisel, showed remarkable qualities. It would not only scratch glass, but also quartz crystal. It was quite tough at ordinary temperatures, and would cut small chips or shavings from a piece of stellite. At a bright yellow heat it showed signs of fusion, and became covered with a skin of oxide.

"An alloy was made by melting the following in a special crucible: cobalt rondelles, 80 g.; chromium, 20 g.; tungsten, 7 g.; calcium silicide, 10 g.; calcium carbide, 5 g. As soon as the above were melted, the crucible cover was removed, and 15 g. of an alloy of cobalt and boron was introduced. The crucible lid was then replaced and the heating continued. A heavy, thick slag formed, which was removed before pouring the metal. The resulting bar was very hard and elastic, but only drew slightly under the hammer, and then broke. A cold-chisel made from the cast metal cut iron readily. The bar was broken up and remelted with about one-third of its weight of an alloy of cobalt, chromium, tungsten and carbon. The result was a fine-grain alloy which was very elastic and would draw out to a considerable degree under the hammer without checking. Its elastic limit must have been very high, since when it broke, the pieces were thrown violently.

"Taking the alloy of chromium and cobalt as a basis, and holding the proportion of chromium at 15 per cent of the entire mixture, it was found that the alloy gradually increased in hardness with the percentage of tungsten. When the quantity of tungsten rises to 5 per cent, the alloy becomes distinctly harder, particularly when forged under the hammer. When the tungsten reaches 10 per cent, the metal still forges readily, and a tool formed from the alloy takes a fine cutting edge. This alloy is suitable for both cold-chisels and woodworking tools.

"When the tungsten rises to 15 per cent, the metal can still be forged, but great care is necessary in order to avoid checking. This alloy is considerably harder than that containing 10 per cent of tungsten, and is excellent for cold-chisels. When the tungsten rises to 20 per cent, the alloy is still harder, and can be forged to a small extent. It makes good lathe-tools for cutting steel and other metals at moderate speeds. When the tungsten rises to 25 per cent, a very hard alloy results, which cannot be forged to any extent, but casts readily into bars which may be ground to a suitable form for lathe-tools.

"These tools have shown great capabilities, particularly for the turning of steel, since they are very strong and retain their hardness at speeds which almost instantly destroy the cutting-edge of a steel tool.

"The tungsten may be still further increased to 40 per cent, and the alloy will retain its cutting qualities, and for turning cast iron this alloy answers even better than that containing 25 per cent. When the tungsten reaches 40 per cent or more, the alloy becomes so hard that it will not only scratch glass but will readily scratch quartz crystal. A small drill made of this material drilled a hole through the wall of a glass bottle without the addition of any liquid or other lubricant.

"A ¼-in. square cast bar, when ground to a suitable edge, was set in a tool-holder attached to a lathe. The workman who had operated the lathe had been able to turn to form 26 cast-iron wheels in 10 hours with a steel tool of the same size. The stellite tool turned 49 of these wheels to form in the same time. The steel tool was ground 50 times during the operation, while the edge of the stellite tool was dressed slightly by a carborundum whetstone after its day's work.

"A set of steel cutters, placed in the boring head of a cylinder-boring machine, was able to bore from 27 to 28 holes in 10 hours. These cutters were replaced by others made of stellite, which performed the work in 3 hours and 20 minutes, or a little more than one-third of the time. Not only was the speed of the mill doubled, but the feed also, and notwithstanding this severe ordeal, the stellite cutters were only slightly worn, while it would have been necessary to re-grind the steel cutters at least two or three times for the same service at slower speed.

"Some remarkable result were obtained in the turning of steel on the lathe. For example, a cylindrical bar of annealed nickel-chrome steel, about 2.5 in. in diameter, was placed in a lathe and turned with a steel tool at about as high a speed as the steel would permit without 'burning.' The steel tool was then replaced by one of stellite, and the speed at the same time increased to 2⅔ its former speed. The stellite tool retained its edge under these severe conditions and produced a shaving weighing 1 2/10 lb. in 30 seconds. Just what the effect of the alloy will be in machine-shop practice is at present somewhat difficult to determine. In my opinion, however, it will not fully supersede high-speed steel in the machine shop, but in cases where rapid work is the main consideration, it will, doubtless, replace high-speed steel.

"When molybdenum is added to a 15 per cent cobalt-chromium alloy, the alloy rapidly hardens as the molybdenum content increases, until the content of the latter metal reaches 40 per cent, when the alloy becomes exceedingly hard and brittle. It cuts keenly and deeply into glass, and scratches quartz-crystal with ease. It takes a magnificent polish, which it retains under all conditions, and on account of its extreme hardness, its surface is not readily scratched. When 25 per cent of molybdenum is added to a 15 per cent chromium alloy a fine-grained metal results, which scratches glass somewhat readily and takes a strong, keen edge. Its color and luster are magnificent and it will, doubtless, find a wide application for fine, hard cutlery. It cannot be forged, but casts readily, and its melting point is not abnormally high.

"If carbon, boron or silicon be added to any of the above alloys they are rendered much harder, though their effect is not always desirable, since they tend to render the alloys more brittle.

"If either tungsten or molybdenum is added to a cobalt-chromium alloy containing 25 per cent of the latter metal, the hardness of the alloy is rapidly increased. When the percentage of tungsten, for example, reaches 5 per cent, the alloy can be readily forged, and forms an excellent combination for woodcutting tools, such as chisels, pocket-knives, etc. When molybdenum is added to the same mixture of chromium and cobalt, much the same effect is produced, though, generally speaking, a smaller quantity of molybdenum is required to produce a given increase in hardness. In some instances I have found it advisable to add both molybdenum and tungsten to the cobalt-chromium alloys. Generally, the color and luster of these alloys, after polishing, are magnificent and they seem to resist atmospheric influences equally as well as the binary alloy of cobalt and chromium."

Mr. Haynes had exhibited a number of most interesting samples of various products made from his alloy, to which he has given the trade name stellite. He emphasized that some of the alloys are almost immune to chemical influence, for instance, absolutely immune to nitric acid and almost so to hydrochloric acid.

In reply to questions as to cutting qualities of stellite as compared with high-speed tool steel, Mr. Haynes said that the superiority of the stellite tool is its ability of cutting more rapidly rather than cutting harder stuff. Further, the stellite tool stands up better; it is not to be ground so often as the best high-speed tool steel. The tensile strength of stellite varies greatly like that of steel.

Stellite is, however, much more expensive than high-speed tool steel on account of the higher initial cost of the starting materials, but for purposes where rapid work is an important consideration the savings which çan be obtained with stellite will compensate the higher cost.

* * *

By=Product Coke Ovens.

There were three papers on this subject presented, the authors being Messrs. Blauvelt, Andrews and Lucas respectively, and a long and animated discussion followed in which Dr. Schniewind and Mr. Blauvelt were the chief speakers.

Mr. Blauvelt's Paper on Coke.

Mr. **William Hutton Blauvelt**, of Syracuse, N. Y., in his paper on "Manufacture of Coke" referred to the coals suitable for coking, the best cell structure of coke for blast furnaces and for foundry purposes and the detrimental effect which oxygen in coal has on the coking qualities.

For many years the bee-hive oven was the standard for coke making, and has remained the standard in England and America long after its practical disappearance from continental Europe. There are several reasons for this. In England, the Durham coal, and in America, the Connellsville coal, are remarkably well suited to the conditions of the bee-hive oven, so that the best quality of coke could be produced without difficulty and with relatively good economy. In America the bee-hive oven had certain economic advantages. It is quickly built and at relatively low cost and the labor required for operation is of low grade. It can be put out of run at relatively small loss during periods of industrial depression and can be started up again with ease after a shutdown. These qualities adapted it to the fluctuating and changing conditions which for many years surrounded our iron industry. But the iron industry has become more stable; and moreover, the coals best adapted to the bee-hive oven are growing scarcer, especially with the exhaustion of the Connellsville field.

From 1907 to 1911 there was an increase in by-product coke of 40 per cent, and a decrease in bee-hive coke of 22 per cent, so that in 1911 the tonnage of by-product coke was 28 per cent of the bee-hive tonnage. By-product plants now under construction and in contemplation will greatly increase the present output.

The bee-hive oven is usually located at the coal mine. The by-product oven is usually located, in this country at least, at the point of consumption of the coke or at some center of distribution. This freedom of choice of location of the by-product oven has a number of advantages. One advantage is that it permits a convenient assembly of several kinds of coal at the ovens because mixing has become quite popular.

There has been much discussion regarding the relative cost of bee-hive and by-product oven plants. It is difficult to make an exact comparison, since the functions of the two types are quite different. For example, in many cases the cost of a by-product oven plant includes a large expenditure for coal storage of several hundred thousand tons in order to take advantage of water freight rates. On the other hand, bee-hive plants are often built in connection with coal-mining plants and utilize a share of power plant, water supply, etc., without having these necessary adjuncts included in their capital account. Careful inquiry into the actual cost of bee-hive oven plants shows that to build such a plant complete in every respect, and in the best manner, including all the equipment besides the ovens and their immediate appurtenances, such as electric power plant, water supply, railroad approaches and sidings, coal handling, etc., would require an expenditure of about $950 per oven.

The P. S. Geological Survey report for 1911 gives the tonnage of coke produced per active bee-hive oven at 466 tons per annum. This figure is, doubtless, low for the best bee-hive ovens; 675 to 700 tons per annum will, perhaps, represent fairly the average output per oven of a modern bee-hive plant. An average of these figures gives a plant cost of $1.38 per ton of coke produced per annum.

A by-product oven plant of say 80 ovens, complete in every respect, and built in the best manner, would produce say 425,000 tons of coke per annum from an average coal and would cost say $1,100,000. Of course, this figure would be varied by local conditions. This is equal to $2.58 per ton of coke per annum. On the basis of these figures a by-product plant costs 86 per cent more than a bee-hive plant.

The owner of a small acreage of coking coal might perhaps well hesitate before making the larger investment, as compared with a simple plant of bee-hive ovens, but, as a general proposition, there hardly seems to be a question as to which style of oven is the better investment. Much of the additional cost of the by-product plant per unit of coke produced is, of course, due to the installation of the apparatus and buildings for the recovery and treatment of the by-products. Other important items are provisions for coal and coke storage, thereby assuring uniformity of operation and greater ability to maintain uniform deliveries. Moreover, a by-product plant is built for a longer life than a bee-hive plant. Eight years may perhaps be considered as a satisfactory life for a bee-hive oven plant, while double this term, or 16 years, would be several years within the life of a well-built by-product plant.

America now leads Europe in output of plant, size of oven, and rate of coking. In the early days of the by-product oven in America the capacity of the oven was about 4.4 tons of coal per 24 hours and twenty-five ovens were considered about the right number for one crew of men. Modern ovens have a capacity of as much as 20 tons of coal per oven per day, and by the introduction of more machinery and more efficient design, the number of ovens handled per man is also increased greatly. The rate of coking is one point in which American practice has gone ahead of Europe.

Retort ovens have been built of various widths from about 14 in. to about 30 in., to suit various ideas of the designers, and various coals; but, within limits, the rate of coking per inch of coal does not vary materially with the width of the oven. Not many years ago the best rate of coking was about 1 in. of oven width in 90 minutes; that is, a 16-in. oven which is coked in 24 hours. To-day there is more than one type of oven which is coking regularly at the rate of from 50 to 55 minutes per inch of oven width. This increased rate was made possible partly by better control of the heating system and partly by the adoption of silica brick in the oven construction.

During the past few years special study has been given to the heat economy of the retort oven and material advance has been made. From most American coals more gas is produced than is necessary for heating the ovens. The conditions under which it is to be operated have an important bearing on the design of an oven plant.

It may be said that there are three general conditions: *First*, where there is not sufficient market to dispose of the sur-

plus gas. In this case the design of oven should be very simple. Any complication of the design for preheating the air should be avoided, since satisfactory coking temperatures can be maintained with cold air, if economy of gas is no object. Steam for the operation of the plant should be raised by burning the surplus gas under simple boilers.

The *second* condition is where there is a market for the gas, perhaps for industrial purposes, but at a low price, and the cost of coal and labor is relatively high. In this case the oven design should provide for partial heating of the air, with proportionate economy of gas for heating the oven, so that the remaining heat in the waste gases is just about sufficient to furnish the steam required for the plant.

In the *third* case the gas is salable at a good price, so that it is desirable to recover the maximum amount for sale. Under these conditions an oven design is justifiable which, while more costly in construction, is most economical in heat consumption. The air is heated in the best form of recuperators or regenerators to 1000 deg. or 1100 deg. C., and the waste gases go to the chimney too cool to be of value. Under these conditions coal and coke breeze are used for producing the necessary steam. Whether steam is used for the production of power, as well as for the distillation of ammonia, heating, etc., or whether the power is generated by gas engines, depends upon the relative market value of coal and gas.

The following tabulated data show in a general way what may be expected from plants designed for the three conditions mentioned above. The figures show the results per ton of coal coked. They represent average conditions and average coals, and, of course, would be modified by special conditions.

Type of Oven.	Fuel gas, per cent.	Surplus gas, per cent.	Steam produced. pounds.
No air preheating	70	30	1050
Partial air preheating	60	40	800
Maximum air preheating	40	60	0

The tendency of modern retort construction, especially in America, is towards the highest economy of heat, even at the expense of simplicity and economy of construction. The proper heating of a retort oven is not a simple problem. It consists essentially in the distribution of heat from burning gases over the side wall of the oven, which presents an area from 35 to 40 ft. long and from 8 to 12 ft. high. The temperature over this entire area must be always under accurate control. When operating for maximum output the temperatures must be held at a point not far below the softening point of the brick, and since the oven chamber is wider at one end than at the other, to permit easy discharge of the coke, the heats must be modified accordingly, so that the whole charge may be coked in the same time. It is also often desirable to maintain a somewhat lower temperature in the upper part of the oven. The combustion of the gas with air which has been preheated to, say 1100 deg. C., as it is in the latest regenerator ovens, produces a theoretical flame temperature of about 2400 deg. C. The actual temperature produced would be much above the melting point of the best refractory brick, and while economical operation demands a full utilization of the best temperatures attainable, the walls of the combustion flues must not be injured nor must there be "hot spots" or "white ends" that will overburn the coke in the adjacent part of the oven chamber.

Fig. 2 shows diagrammatically the application of the heat in the different types of ovens. *A* indicates the combustion flue system of any retort oven with its regenerative chambers below. *B* and *C* show applications of this general arrangement as adopted by oven systems employing vertical flues. *D* shows the application to the horizontal-flue ovens of the series type. *E* a horizontal type where all the flues are in parallel. *B*, *C*, and *D* represents the methods generally adopted in commercial ovens.

In the former type, or the vertical-flue oven, the gas and air are mingled and burned in horizontal flues at the bottom of the vertical flues, the burning gases distributing themselves and passing up one-half the vertical flues and down the other half, as indicated in the sketch; or gas and air are led separately to the bottom of each of the vertical flues, where they are mingled by properly arranged nozzles and burned as they pass upward. In some ovens a combination of these different methods is adopted.

HORIZONTAL FLUE-OVEN DESIGN.

D illustrates the horizontal series-flue regenerator oven; and, as Mr. Blauvelt has had more experience with this type, he discusses somewhat in detail the principles of its operation. All of the air required for the combustion is passed through the
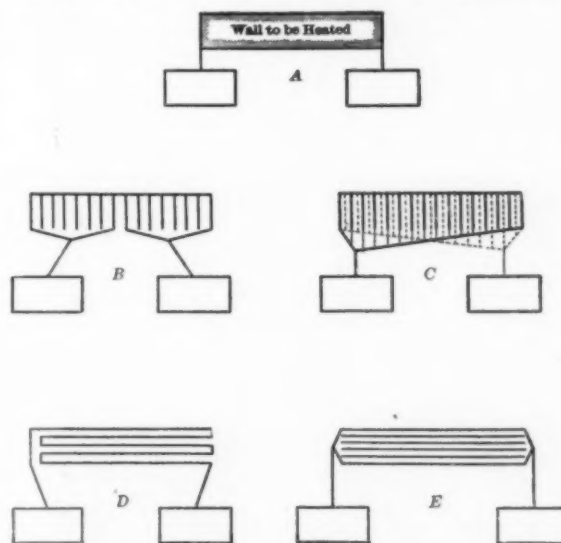

FIG. 2.—APPLICATION OF HEAT IN DIFFERENT TYPES OF COKE-OVENS.

entire flue system, first from above downward, and then from below upward, as the regenerator system is reversed. The heating gas is admitted at the end of the flues, usually in four or five places, as may be required.

This method seems to give a maximum of simplicity. The flow of gas is automatically reversed in the flues themselves by the change in the current of air. Every flue may be conveniently inspected from end to end by a man walking along in front of the ovens, and the gas admission at each point is directly under his hand, so that there is no excuse for failure to immediately observe and correct any tendency to unequal heating.

The distribution of the heat throughout the flue system is made remarkably uniform by this process. This is partly due to the comparatively high velocity of the gases sweeping through the flues and to the fact that the gas is burned either in a large excess of highly heated air, or else in a mixture of air and products of combustion. The advantages of the presence of products of combustion in the combustion chamber, where it is desired to obtain a distribution of heat, have been clearly shown in other combustion processes, such as the Doherty system of producer operation, for example.

In beginning the experimental work leading up to the present method of operation, while it was recognized that the presence of a large volume of air, together with products of combustion mixed with the burning gas, was an important factor in distributing the heat with uniformity, yet it was feared that passing the entire volume of air through all the flue system might seriously increase the friction and make the maintenance of sufficient draft a difficult matter, even though the total amount of air admitted could be accurately proportioned so that it would be just sufficient to burn all the gas.

Hence, an oven was designed with the flues in parallel, in order to reduce the velocity of the gas currents, following the principle of the vertical-flue type. It was found, however, that the velocity of the gases passing through the flues did not produce material friction loss, but that most of the friction arose from eddies in the currents at the ends of the flues; and by a suitable modification of the structure at these points it was easy to keep down the draft required to a reasonable amount, while maintaining the velocity of flow that was so effective in securing uniform heats.

This method of handling the gases through the flues in these series-flue ovens has, therefore, two advantages. It is effective in distributing the heat uniformly from one end of the flue to the other, and at the same time the higher velocities effect a more efficient transfer of heat through the flue wall. The effect of velocity of travel on the transfer of heat through walls has also been shown very clearly in a series of experiments on steam boilers made by the Engineering Experiment Station of the University of Illinois.[1] It will be remembered that these tests were undertaken to determine the relation of heat transmission to velocity of circulation in the steam boiler. They show very clearly the important effect of velocity flow on rate of heat transmission, and from the deduction therein set forth it would appear that the same conclusions may be drawn in the study of our problem.

Having obtained by these means such an effective distribution of the heat, the arrangement of gas admission to the flue system makes it easy to control the temperature of the whole system under the severe conditions described above. The result is that in this type of oven the heat is remarkably uniform from end to end, hot or cold spots are practically unknown, and the control of the temperature is much easier than ever before.

The temperatures maintained in the flue system depend, of course, upon the rate of coking it is desired to maintain. They usually run from 1000 to 1250 deg. C., or somewhat higher. The temperature at the point of entrance of the heated air is controlled by the admission of the proper supply of gas, and additional gas is introduced at other points in the system in order to make up for the heat transmitted into the oven chamber, or to augment the temperatures as may be necessary in preserving the proper relations of heat in the different parts of the system. The periodical reversal of the gas currents prevents any tendency to inequalities which might otherwise develop.

The perfecting of this system makes the regenerative retort oven quite as simple and easy to operate as the recuperative oven, and at the same time secures the maximum heat economy. There is only one reversing valve on each oven block, by which the currents of air and products of combustion are reversed through the system, and this may be easily operated by a simple mechanical device with time control. All the other advantages of the older system, of simplicity and reliability of operation, are maintained.

This type of oven utilizes the principle of a heavy wall between each two oven chambers. This wall occupies some room and, therefore, more space per unit of production, yet it has several material advantages. It supports the main body of the oven structure and carries, without difficulty, the weight of the heavy charging cars, which, when loaded, may weigh more than 20 tons. It permits that part of the oven structure which is subjected to the highest heats to be readily repaired, or even entirely replaced, without effecting the integrity of the main structure and also without stopping adjacent ovens. Another value of these intermediate walls is that they act as a reservoir of heat. They accumulate heat during the coking process and when fresh coal is charged they come to the assistance of the burning gas and help the oven pick up its heat and maintain a coking temperature.

While the earlier by-product oven plants were simpler in de-

[1] *Bulletin No. 40, University of Illinois* (1909).

sign and equipment, the modern plant is almost entirely mechanically operated, and electrically driven machinery has taken the place of most of the hand labor.

BY-PRODUCTS.

During the development of the by-product oven in the last few years much study has been given to increasing the effectiveness and economy of the apparatus for recovering the by-products. This recovery consists essentially in the cooling of the gas, which causes the condensation of much of the tar vapor and water vapor, which latter brings down with it part of the ammonia. After cooling, the gas is scrubbed in contact with water, sometimes by passing it through tall towers through which water is showered, sometimes by bubbling through water in a series of shallow pans, or by other methods; the object in all scrubbing processes being to bring the gas in contact as intimately as possible with wetted surfaces, to take advantage of the strong affinity of water and ammonia.

The weak ammonia liquor produced in these processes is distilled by steam, producing either the ammonia liquor of commerce, or, by more refined operations, the purer grades of ammonia. If the ammonia gas from the stills is passed into sulphuric acid, ammonium sulphate, one of the most important artificial fertilizers, is produced.

Much work has been done lately on what are known as direct processes for the recovery of ammonia. In all these processes the gas is passed directly through a bath of sulphuric acid, thereby turning the ammonia into sulphate. Several such "direct" processes have been worked out, the difference being principally in the method employed for the removal of the tar from the gas, which is then bubbled through the sulphuric acid bath; the ammonium sulphate settles out and is removed, and the gas is ready for further treatment. At this point the light oils are removed or the gas is sent direct to the point of consumption. Several methods have been advocated for the utilization of the sulphur in the gas itself as the source of sulphuric acid for making the sulphate. These processes are somewhat complicated.

One of the latest applications connecting the manufacture of coke with the other arts is the "gas oven." This name has been applied to the by-product coke oven when adapted especially to the manufacture of illuminating gas. The essential modification is that the gas for heating the ovens is obtained from producers, the ovens being modified to suit this gas, so that the whole of the gas produced from the distillation of the coal in the oven is available for sale as illuminating gas. This adaptation of the retort oven is attracting considerable attention; several plants are in operation in Europe, and three or four are beginning operation or are in course of construction in the United States. While producing practically the same gas as other systems employed in coal-gas manufacture, the gas oven has the advantage of producing a high quality of coke. It also has the advantage in operating cost, due to the employment of larger units and carbonizing more coal per unit of labor. These plants are more especially adapted to the larger installations for gas manufacture.

In discussing the use of by-product coke for metallurgical purposes, the statement is often made that this coke cannot be as good as bee-hive coke, because the quality of the coke is injured in the manufacture in order to obtain better by-products. This is not the fact, as is borne out by the considerable number of by-product oven plants now supplying metallurgical coke for furnace and foundry work. In fact, in a number of localities by-product coke is sold for foundry purposes at a premium over the best bee-hive coke on the market.

One point in which by-product oven operation has improved in recent years is in reliability. In considering the gas, for example, either for gas-engine work or for illuminating purposes, reliability of supply is an absolute essential; and while formerly the supply of gas was uncertain and undependable, contracts are now made which insure a permanent and reliable

supply that can be depended upon, like any other manufactured product. The sales of oven gas for illuminating purposes now exceed 40,000,000 ft. per day.

The manufacture of by-product coke is coming to be not only an operation for the manufacture of coke and the saving of such incidental products as may be obtained, but rather an industry where coal is distilled for the purpose of producing several products, such as coke, tar, ammonia, benzol, gas, and perhaps others, each made of the best quality, and each important in maintaining the earnings of the plant. The growth of chemical manufactures in America and the greater demand for the products which supply these industries add permanency and reliability to the market, and at the same time the by-product oven furnishes a reliable supply of raw materials to important industries, which, although in some cases still in embryo here, have attained great proportions in Europe, and doubtless will grow to large importance in this country.

Mr. Andrews' Paper on By-Product Coke.

The paper by Mr. Charles W. Andrews, of Duluth, Minn., on "By-Product Coke," was presented in the absence of the author by Dr. Schniewind. He first gives a breif sketch of the developments of the by-product coke industry in the United States since 1893.

The New England Coke & Gas Company started the plant in Boston in 1899 which was destined to change the whole trend of the establishment of by-product plants, since it manufactured for the first time illuminating gas suitable for sale without enrichment. This was accomplished by dividing the gas on the battery into two portions. One portion consisting of the richer part of the gas was saved 'for sale, while the remaining, or leaner, portion was used in the battery.

This idea was originated by Dr. Schniewind, of the United Coke & Gas Company. The coke was used for domestic, industrial and locomotive fuel, as its sulphur content was too high to make it suitable for use in the foundry. The successful operation of this plant led to the building of additional plants at points where the production of illuminating gas could be sold to advantage and where there was a fair market for the coke output.

The author gives a list of illuminating-gas plants showing the rapid growth of this method of combined gas in coke manufacture, and also a list of by-product coke plants at iron and steel centers. The latter list shows that with comparatively few exceptions all the steel plants and blast furnaces lying outside of the coking-coal district receive almost their whole coke supply from the by-product ovens. This is a most decided change from fifteen years ago when Cambria was practically alone in the field.

The question is often asked why by-product ovens are not being built more freely in the central coking districts. To answer this question statistical figures are given showing the decline of the production of coke in bee-hive ovens and the increase of the production of coke in by-product ovens in recent years. As a very large proportion of the total bee-hive coke is produced in the central coking district, the present bee-hive ovens are ample to take care of the demand during ordinary years, consequently if the by-product plants were built by the present operators it would result in the loss of a large investment in bee-hive ovens necessary for a corresponding output. In addition the operators would practically be unable profitably to sell the gas for illuminating purposes owing to the competition of natural gas.

There is no doubt but that the gradual exhaustion of the coal and gas fields will eventually lead to the use of by-product ovens throughout the district, since the increase of practically 10 per cent in yield obtained by the by-product ovens, and a market for illuminating gas will eventually become of enough importance to justify the move.

As far back as 1898 the use of producer gas to heat the ovens either wholly or in part was suggested by Dr. Schnie-

wind and an experimental installation was made at Boston for this purpose. Its use, however, was not extended owing to various reasons. Within the last two or three years, however, conditions at certain points have become more favorable for this form of gas production, and several systems have been devised whereby combination ovens are constructed. These ovens are so designed that either producer gas or lean oven gas can be used for heating the brickwork. In this way the ovens can be designed to take care of the summer consumption under most favorable conditions, and a producer-gas plant can take care of the increase in the winter consumption. This development will, no doubt, lead to the construction of a large number of comparatively small by-product plants throughout the United States. These plants would ordinarily make sufficient metallurgical coke to supply the needs of the local foundries and sell the remainder of the production for domestic use.

Apparently the final result of by-product oven construction will be the gradual spread of coke manufacture over practically the whole country instead of in the coking-coal districts.

Mr. Lucas' Paper on Coke.

A paper by Mr. F. E. Lucas, of Sydney, N. S., on the manufacture of coke was read, in the absence of the author, by Mr. Blauvelt. Coal is in a chemical respect coal with the volatile material distilled off, but it must also conform to certain specifications in respect to physical structure and the percentage of impurities present. The impurities in coke are principally sulphur and ash, of which the first gives the most trouble.

In this country we have had in the past available large quantities of coals which are naturally of a good coking quantity and require no preparatory treatment. The exhaustion of these coals is in sight, and it will in the future be necessary to put the coal through certain processes before charging in order to maintain the standard of coke.

If a coal is high in sulphur or ash it will have to be washed to remove as much as possible of these impurities. The mechanical devices employed for doing this are many and varied, but any one type of plant does not necessarily work to the best advantage on every coal. Each coal should be carefully studied and tested by all possible means before erecting any plant to prepare it for coking.

A further preparation which may become necessary will be the compression of the coal into cakes before charging. It is sometimes claimed that all coal should be stamped before charging, but the author does not agree with that claim. Compressing a coal which gives us under natural conditions such a coke as is desired, only closes in the cell structure and makes a heavier and denser coke. However, this does not alter the fact that in many cases compression of the charge is of incalculable benefit to the quality of the coke produced. Both washing and compression are almost universally practised in Europe.

The author then gives a sketch of the process of making coke and recovering by-products applicable to all kinds of by-product coke ovens. The part relating to by-products is here reproduced.

RECOVERY OF BY-PRODUCTS.

The recovery of by-products in their first form takes place in the condensing plant. During the past few years there have been many new developments in recovery apparatus.

The older method of extracting tar and ammonia from the gas was to pass the gas through a series of coolers, bringing it down gradually to the vicinity of from 80 deg. F. to 90 deg. F., then pass it through the tar scrubbers, and then through the ammonia washers, where the gas was brought by various means into intimate contact with water. The water absorbed the ammonia, and this ammonia liquor was then distilled by steam, the ammonia vapor being driven off, and, in turn, absorbed in a bath of sulphuric acid, in which the ammonium sulphate was precipitated, and afterwards extracted and dried, ready for shipment.

The next process was a semi-direct one, in which the gas was cooled sufficiently to allow the tar to be extracted by the ordinary cooling method, and then the gas was heated up again and all passed through the sulphuric acid bath, which absorbed all the ammonia, while the gas passed on to the holder or oven. The sulphate in this case was precipitated and prepared for shipment as in the previous process.

In the semi-direct process a certain amount of weak ammoniacal liquor, consisting of the moisture which was condensed out of the gas in the original cooling, has to be dealt with in stills, the same as in the first process. The quantity of the liquor to be so dealt with will depend on the moisture in the coal charged into the ovens.

A third—the direct—process, consisting in taking the gas direct from the ovens without cooling, extracting the tar at this high temperature by specially designed apparatus, and then passing the whole of the gas through the acid bath, as in the previous process. By this method there is no liquor to be dealt with and there is also no lime needed in the process, as in the case where liquor has to be distilled and a certain amount of milk of lime has to be added to release the so-called fixed compounds of ammonia in the liquor.

There is still another process, as yet in the experimental stage, in which the gas is cooled and the tar extracted as in the process first described, but the ammonia is recovered in the form of sulphate by utilizing the hydrogen sulphide in the gas instead of sulphuric acid.

QUENCHING OF COKE.

The quenching of the coke is important from both the standpoint of moisture content and of strength. If the coke gets too much water, the cells will suck themselves full as they cool and there will not be heat enough left to expel this excessive moisture. At the same time, the rapid formation of steam has a tendency to crack the coke and weaken it materially. The ideal quenching of coke can be shown by immersing a piece in water, just for a moment, immediately after it comes from the ovens, and then leaving it for about 20 minutes. The water has just chilled the outside and stopped any tendency to combustion there. The inside will die out for want of air, and at the same time there will be sufficient heat to dry out the moisture from the outer cells. It is probably not possible in actual practice to get such results as we would in a small experiment, but the nearer we approach to it, the better the product will be.

The effect of moisture in the coke is one on which opinions may differ. The buyer of the coke, of course, does not care to pay for the moisture contained or pay freight on it. But the effect of moisture in the coke on the action of the furnace or cupola itself is not so clear. In the foundry cupola, where the ratio of coke to iron melted is so low and the distance between the top and the melting zone so short, the question of moisture may be very important; but in the blast furnace we have a very different condition. The author does not see how a reasonable amount of moisture in the coke can affect the melting zone of the furnace or the reducing action of the gas on the ore. There is a temperature at the top of the furnace, where the coke is charged, high enough to thoroughly dry out the moisture before the coke gets far enough down to do any good, and the moisture is carried off with the gas. In fact, there are some furnace plants where the coke is sprayed with water before charging in order to keep the top heat down below the danger limit.

Then comes the question of the effect of the moisture on the gas itself. As long as the moisture is not high enough to limit the heats required to be raised on the stoves, the author cannot see that it has done any harm.

The author emphasizes that manufacture of coke in beehive ovens is probably the greatest waste this country has ever seen. The by-product oven gives besides the coke also surplus gas which may be used for gas engines or as an illuminating gas, further, ammonia and tar.

In the year 1911 there was produced in America approximately 29,338,000 tons of coke, of which approximately 21,448,000 tons was produced in bee-hive ovens. If these tons of coke had been produced in by-product ovens instead of bee-hive ovens the author figures that there would have been produced surplus gas of a value of $10,400,000, ammonium sulphate at a value of $10,446,000, and tar at a value of $3,640,000; the total value of ammonia and tar being $24,500,000.

The above amount is 7 per cent on about $350,000,000, a sum which would build by-product ovens enough to carbonize 125,000,000 tons of coal yearly. Besides this loss, there has been the loss of the coal burned in the bee-hive oven. Allowing 64 per cent as a fair yield for the bee-hive and 78 per cent for the by-product ovens, there would be a loss exceeding 6,000,000 tons of coal. This at $1 per ton added to the other loss gives us a grand total of over $30,000,000 lost in one year. It seems that this is well worth "getting after." The author finally gives a detailed comparison between bee-hive and by-product ovens and figures that for a plant of 100 by-product ovens with an oven charge of 9 tons the yearly saving would be $455,155. The cost of the 100-oven plant complete is approximately $1,000,000. A 100-oven plant of above capacity will produce 630 tons of coke per day = 229,950 tons per year, working on 24-hour coking time. If benzol is recovered it will further add to the income from by-products.

Discussion on Coke.

The three papers were taken up together and elicited an extended and spirited discussion in which Messrs. James E. Thropp, Jr., James F. Kemp, E. V. d'Invilliers, F. Schniewind, R. Moldenke (in a communicated discussion), Bradley Stoughton, H. H. Stoek, Charles H. Fulton, Ralph H. Sweetser, and W. H. Blauvelt participated.

In reply to the question as to what the maximum percentage of oxygen is which is permitted in coking coals Mr. Blauvelt said that this varied, but an oxygen containing 8 or 9 per cent would probably be considered high. Dr. Schniewind said that the oxygen alone was not the deciding factor; it is the relation of oxygen to nitrogen, the combination being in the ratio of 8 to 1. With respect to the swelling of coke, Mr. Blauvelt said that many low volatile coals swell considerably, but that the tendency of swelling could be counteracted by mixing such coal with other coal.

Dr. Schniewind discussed at considerable length the question of vertical versus horizontal flues and some essential details of operation in Otto-Hoffman versus Semet-Solvay practice. He thought that the general and logical practice of circulating gases was in a vertical direction. In his practice he found it necessary to provide for a slow travel of the gases and an absolute exclusion of external gases. He thought that Mr. Blauvelt's reference to boiler practice was not conclusive since the heating conditions in a boiler and in a coke oven are very different. Dr. Schniewind emphasized his opinion that in the boiler we have to do with transfer of heat by convection and in the coke oven with transfer of heat by radiation. The temperature difference is very different in both cases. When heat is transferred by convection it is necessary to provide for rapid movement in order to remove the adhering film from the flues, but it is not so in coke ovens, where radiation of heat counts and where it is found in practice that a slow movement of the gases improves the operating conditions. He also thought that the partition walls in the Solvay ovens were detrimental.

Mr. Blauvelt, in his reply, doubted the correctness of Dr. Schniewind's distinction between heat transfer by convection and radiation in case of boilers and coke ovens respectively. (Professor Fulton suggested later that what Dr. Schniewind meant was not a convection, but a conduction of heat.) As to the middle walls in the Semet-Solvay ovens he agreed that they take some space, but besides the other advantages stated in his paper above he emphasized that they were very useful as a reservoir of heat which comes very handy when a fresh charge of coal is introduced.

Mr. E. W. Parker, of the Geological Survey, said that last year the value of by-products obtained from by-product coke ovens was equal to the value of the coal charged into the ovens. Mr. Blauvelt warned the hearers not to take this statement as meaning that the coke didn't cost anything.

Mr. Bradley Stoughton referred to the successful use of tar in open-hearth furnaces as fuel by one steel company in this country. When more by-product coke ovens are erected there will hardly be much trouble in finding a market for by-products.

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The Concentration of Iron Ores.

A paper on the concentration of iron ores was presented by Mr. **N. V. Hansell,** of New York. The importance of the concentration of low-grade iron ores lies not only in the fact that it makes possible the use of ores heretofore discarded, but also in the production of a raw material for the blast furnace that is physically more uniform and chemically purer, and may therefore command a higher price in future.

The various methods at present commercially used in the concentration of iron ores can be classified as follows:

1. Washing of brown, clayey ores and sandy hematite usually without previous crushing.

2. Wet separation on jigs and tables of hard hematites, after crushing and sizing.

3. Dry separating processes of hematites.

4. Magnetic separation of magnetites (and in a few cases mixed magnetites and hematites) either dry or wet

The choice of a method depends almost entirely on the character of the crude ore. It is first necessary to carefully investigate the ore in the field and in the laboratory (where much useful information may be derived from microphotographic methods) and this is to be followed by crushing and concentrating tests in the testing plant.

The next chapters of the paper summarize recent progress in crushing, washing, jigging, dry concentration and magnetic saturation. Since these chapters are already in the form of greatly condensed information it is impossible to abstract them further.

In conclusion the author makes the following remarks:

In making the first rough estimates on the probable revenue in the exploitation of a low-grade concentrating iron-ore, proper attention must necessarily be given to the tonnage of ore available and to the cost of mining it. Generally, any low-grade proposition requires the investment of a large capital in a concentrating plant and in many cases in an agglomeration plant, indispensable for the conversion of the fine concentrate into a marketable product. The operations have therefore to be laid out in a large scale because otherwise the fixed charges distributed on the tonnage will make the cost of production seem prohibitive. A large tonnage of ore in sight, insuring operations in large scale for a number of years, is therefore a prerequisite.

In the case of iron ore, it is generally not difficult to predetermine the available supply of ore, and with magnetic ores it is even easier than with hematites, because the magnetic qualities of the ore make it convenient to employ some method of magneto-metrically surveying the ore deposit. If correctly done, this will give the extent in field of the ore deposit together with useful data on the dip and pitch. By a few diamond-drill holes, where the magneto-metric map indicates the best location for them, the quality of the ore in depth and its continuity are determined.

With these preliminaries well done, the development of the deposit can be quite accurately planned. The cost of the various operations can be estimated very closely from figures obtained elsewhere in similar undertakings, and modified to suit the local conditions as experience dictates. The usual risk generally considered inherent to mining enterprises is almost entirely absent. The consumption of iron ores is large

and as a rule increasing from year to year. The American production of pig iron during the last 100 years has on the average somewhat more than doubled in each decade. The market is therefore well established. The market price of the ore has varied considerably and has, the last couple of years, been very low. It is, however, at present improving. In the light of the rapidly growing consumption it is not assuming too much to believe that it will never reach a lower point than it has in the past season. The easily available ores of good quality are, as is well known, very limited in extent and are controlled by companies not desirous of exhausting them at too rapid a rate. The foreign ores of high grade are available chiefly on the coasts. Their transportation far inland would make their cost prohibitive.

By taking all these conditions into consideration, one can feel reasonably certain in calculations of the probable revenue in the development of a low-grade iron ore proposition, using the present ore prices at the various furnace districts as a basis in finding the value of the concentrated and agglomerated product.

It is interesting to compare the various items of cost entering into the production of a high-grade blast-furnace material from a low-grade magnetic ore. We may take as an example an ore averaging 36 per cent. of iron in its crude state and occurring in such a large deposit that for several years to come it can be mined in open quarry and loaded with the steam shovel. If the intention is to produce concentrate with 64 per cent. of iron, it will be necessary to mine two tons of crude ore to make one ton of finished product.

The plant is, we will say, laid out for the treatment of 2000 tons of crude ore daily, which corresponds to 1000 tons of concentrate in 24 hours. A plant of this tonnage can be considered of normal size. It is assumed that power can be obtained in the form of water power and that transmitted to the works it does not cost more than $25 per horsepower year.

Labor is calculated at 20 cents per hour. The quarry and coarse-crushing plant are operated only in the day time because labor enters heavily especially into the quarry operations, and therefore better economy is obtained by accumulating during the day-shift enough crushed ore, which is distributed in the bins over the fine-crushing plant, to last over night. The quarry and coarse-crushing machinery is also easily obtainable in large units making it convenient and econominal to handle from 200 to 300 tons per hour.

In such a plant the following items of cost would enter into the cost of producing one ton of finished product:

Mining and transportation to crusher	$0.75
Crushing	0.10
Grinding and concentration	0.40
Agglomeration	0.50
Tailing handling and pumps	0.05
Shops, local administration, taxes, insurance	0.15
	$1.95

To this cost of manufacture is to be added the royalty on the ore as mined or as shipped, charges on account of the sinking fund, selling expenses and freight to furnaces. These will probably bring the total estimate for the agglomerated product laid down at the furnace to $3.75 per ton.

As soon as the operations have reached the point where it is necessary to resort to underground mining, the cost of the product will be increased, but the calculations still show a profit in the operations on account of the high quality of the material with its freedom from phosphorus and sulphur, which will make it bring a premium on the market.

The paper was briefly discussed by Messrs. Spilsbury, Moore, Johnson and d'Invilliers, and the question was brought up why expensive processes are now being used on medium-grade ores when the old log-washing process was formerly used on much lower grade ores with success.

Iron Blast Furnace Slags.

Mr. J. E. Johnson, Jr., of Ashland, Wis., then presented his paper on "The Effect of Alumina in Blast Furnace Slags." The author emphasized that most of the work done in the past by scientists on blast furnace slags is of little value for practical purposes since the important point of a given slag is neither its total heat of fusion nor its softening temperature, but its free-running temperature, since this is the critical temperature of the furnace. This temperature bears no definite relation to the softening temperature.

As to slag calculations, any college student can learn in a day how to make them, if there are given to him the materials to be used and the slag to be produced. But, first, the slag to be produced must be known and it is known only by experiment and experience with the furnace itself.

The object to be sought is as follows: Given the materials to be used and the kind of iron to be made, to ascertain the slag which will produce the result with the least cost for coke and for flux, and will permit the greatest out-put. The three desiderata come in the order given.

Since generally the lowest fuel consumption is obtained with the lowest critical temperature, the object desired may be stated more definitely as the production of the most fusible slag that will give the necessary desulphurization of the iron. This statement is perhaps subject to certain limitations from the fact that there are circumstances in which it is necessary to raise the critical temperature in order to enable the iron to absorb a large quantity of silicon.

While the effect of lime is to increase the basicity of slag and facilitate the removal of sulphur, its use is subject to grave limitations, for two reasons: First, the lime being generally the major ingredient of the slag, to increase the percentage of the lime in the slag involves a more than proportional increase in the slag volume.

Second, (and much more important), the addition of lime raises the fusion point of the slag very rapidly.

The desulphurizing effect of the slag is proportional, not only to its basicity, but also to its fluidity in an almost equal degree, so that while increased lime *per se* has a desulphurizing influence, this is, to an increasing extent, neutralized and finally reversed completely by its decreased physical activity.

This is well shown in basic practice, in which the highest sulphur iron is made, not with deficient lime, but with an excess (due to a change in ore or the like) so great that the heat available is unable to bring the very refractory slag to the free-running condition.

In further illustration of the point, there are two distinct methods of making this kind of iron. The first consists in running on a very calcareous slag, with which the silicon in the iron is kept down by the basicity of the slag in spite of the high temperature necessary to keep the latter fluid. The second consists in maintaining a slag of only moderate basicity and much lower fusion temperature and keeping down the silicon by carrying a heavy ore burden, which, of course, can easily be done with the lower critical temperature.

Furnaces running on the first plan always require more coke for basic than for foundry iron, while those running on the second plan use less than for foundry iron.

It seems practically certain, therefore, that there is a considerable range of lime content in the slag for given conditions, in which the desulphurization of the iron is not appreciably affected, while the coke consumption necessarily rises with the increase in the fusion temperature consequent on the high lime ratio, as well as the increased slag volume.

Mr. Johnson then takes up the effect of magnesia and points out in all theoretical slag calculations the quantity of magnesia is multiplied by 1.4 to put it on the same basis as the lime, which, from the point of view of the oxygen ratio and molecular weights, is perfectly correct. Practically, however, this does not work out.

The truth seems to be that magnesia is less active chemically than lime in about the same proportion that its molecular weight is less.

It is very necessary, however, to recognize that the addition of a certain amount of magnesia has a marked effect in lowering the fusion temperature of the slag and is therefore of great use where calcareous slags are required, particularly in the manufacture of basic iron.

For practical purposes lime and magnesia may be considered as being of equal value.

The author then takes up the main subject of his paper, which is the effect of alumina in blast furnace slags.

The effect of alumina has been the subject of much discussion; some regard it as an acid, others as a base, while a few declare it can be made to act as a base or an acid almost at will.

It has seemed to Mr. Johnson that under such circumstances the probability was that its action was neither acid or basic, but was perfectly neutral, simply a diluent affecting the viscosity of the slag to some extent, but, with a given ratio of lime to silica, not affecting its chemical nature at all. The author produced considerable evidence from practice to support the correctness of this view.

The subject was discussed at some length, in spite of the lateness of the hour. Mr. Sweetser said that the paper had opened one of the most useful discussions for blast furnace men, and paid a high compliment to Mr. Johnson's paper, although he did not agree with his views on the effect of alumina.

Prof. Fulton emphasized that the slag composition should be looked upon from the standpoint of physical chemistry. The entities constituting a slag are certain minerals. Most slags consist of two minerals only, which fact simplifies the theory very essentially. On this basis the action of alumina may be simply explained. After some remarks by Prof. Kemp on the fusion point of minerals, the meeting adjourned.

* * *

Business Session.

The whole morning of Wednesday was devoted to a business session which was held again in the Assembly Room of the Hotel Statler. In behalf of a special committee consisting of Dr. Jos. W. Richards, chairman, and Messrs. Charles Kirchhoff and Charles F. Rand, Mr. Rand presented the new proposed constitution for the Institute as worked out by the committee after most painstaking deliberation.

Two special points came in for an extended and animated discussion. The first was a proposition to provide what would be in fact a new and superior class of members, called the "Fellows" of the Institute, and to give them the right to express their opinion with regard to pending or proposed legislation affecting the mining and metallurgical industries.

There were many speeches made both for and against the proposition. For the proposition it was argued that in the past the Institute had been too indiscriminate in electing members and that a class should be made of those members who have the higher qualifications of a mining engineer. Further that it would be advisable that if not the whole Institute, at least somebody within the Institute, should have the right to express an opinion of pending problems of national importance.

Against the proposition it was pointed out that the class of Fellows would represent an organization within the organization. It would be a self-perpetuating body. It would be a dangerous departure from the ideals of the American Institute of Mining Engineers which, as Mr. Johnson said, has always been "the great democratic engineering society." As to the advisability of expressing an opinion on pending problems Mr. Johnson asked: If sixteen years ago the Institute had expressed an opinion on the free silver question in which its members were certainly interested, what would have become of the Institute? Further, the question was asked,

Would it be advisable now for the Institute to express an opinion on the tariff in which the members are certainly interested?

The outcome of the discussion was that it was voted to be the sense of the meeting that the paragraph in the proposed constitution giving the Fellows the right to express an opinion should be stricken out (the vote being 33 to 17). Further, it was voted to be the sense of the meeting that the class of Fellows should not be created (the vote being 27 against the Fellows and 20 in favor).

The second point which came up for extended discussion referred to the question whether the Secretary of the Institute should be restricted to devote his whole time to the Institute. The vote was 30 against this restriction and 13 in favor of it.

Of course, as the proposed constitution will be submitted to all the members for a vote, the vote taken was simply for the purpose of ascertaining the opinion of those who attended the Cleveland meeting and listened to the long and detailed discussion.

The concluding session was held on Friday morning in the Case School of Applied Science, in the large lecture room of the Department of Physics.

* * *

Charcoal Iron.

The first paper was presented by Mr. J. E. Johnson, Jr., on "the effect of carbon on the quality of charcoal iron" which elicited considerable interest and was discussed by Mr. Bradley Stoughton and in a communicated discussion by Prof. Howe. Mr. Stoughton paid a high tribute to the results which Mr. Johnson has already obtained in his scientific research and which he had been able to turn into a commercial or practical success.

Mr. Johnson's paper was illustrated by numerous interesting lantern slides. In view of the importance of the paper it is printed in full elsewhere in this issue.

* * *

The Series of Copper Slags.

Prof. Chas. H. Fulton, of Cleveland, O., in his paper on this subject, pointed out that the classic work of J. H. L. Vogt, who views slags from the standpoint of physical mixtures (solutions in which the entities are minerals), has opened up a new field in the study of slags, and has placed the investigation of such properties as melting temperatures, etc., on a rational basis. The author's own work recorded in the present paper is the result of an investigation of reverberatory furnace slags made for a Western smelting company to determine exactly the influence of change in composition, within comparatively narrow limits, on the melting point.

In view of the fundamental importance of Prof. Fulton's paper it will be printed practically in full in one of our next issues. We give here only a brief summary. After an introduction on the mineral series of copper and lead slags, the author deals with the constitution of certain reverberatory slags and then takes up the melting point of slags giving curves both for the melting point and for the fluidity or free-running temperature. The latter is, of course, the temperature which is of practical importance. The two curves are by no means always parallel and the variation between the two temperatures is quite interesting.

The slags of lower melting point lie roughly between a silicate degree of 1.4 and 1.65, dependent upon the base composition. This confirms what has long been the opinion of copper metallurgists. With a given silicate degree, within the range of 1.70 to 1.00, the replacement of iron and lime by some alumina, up to 11 per cent, lowers the melting point. In a given slag of certain silicate degree within the range specified, the replacement of iron by lime raises the melting point somewhat. This, however, does not mean that a pure ferrous bisilicate, for instance, has a lower melting point than one in which some iron is replaced by lime, for this condition would be expressed by the series hypersthene-augite, in which a eutectic may also occur. It has reference to series of minerals in each of which lime is necessarily present, as sugite-eilite. Then of two slags, each of the same silicate degree, the one with relatively more lime has the higher melting point. The slags investigated have melting points that lie between 970 deg. and 1220 deg. C. The slags of higher silicate degree have comparatively low melting points.

When, however, the fluidity curves are examined in connection with the melting point curves it is seen that the gap between the two curves widens rapidly as the silicate degree increases, and while from 25 deg. to 40 deg. of superheating is sufficient in the vicinity of the ortho-silicate, from 150 deg. to 175 deg. is required to superheat to fluidity at a silicate degree of 1.5. Increased alumina accentuates the gap greatly, and the more highly aluminous slags, due to their great viscosity, require much superheating above the melting point in order to obtain enough fluidity. It is this phenomenon which makes high silica, high alumina slags so difficult to work. The minerals orthoclase and albite, high in alumina and silica, are extremely viscous.

Slags approaching near the bisilicate are looked upon with suspicion for reverberatory furnace work particularly. Of late, however, the incentive to make the more highly siliceous slags has been great. On the score of formation temperature and melting point nothing can be urged against these slags, but they do require much superheating, especially if alumina rises above 5 or 6 per cent. There seems to be no good reason why they could not be made in furnaces of ample temperature reserve, such as the present oil-fired furnaces.

* * *

Metallurgy of Copper.

Two further papers relating to the metallurgy of copper were then presented.

Mr. Frederick Laist, of Anaconda, Mont., read his paper on the chemistry of the reduction processes in use in Anaconda. This paper was already presented before the International Congress of Applied Chemistry and was printed in our issue of September 12 page 592.

A paper by Mr. E. P. Mathewson, of Anaconda, Mont., on the development of the reverberatory furnace for melting copper ores was read by title. It had also been presented before the International Congress of Applied Chemistry, and was printed in our issue of September 12, page 591.

* * *

National Resources and the Federal Government.

A paper by Dr. R. W. Raymond on "our national resources and our Federal Government" was read by title, and Dr. W. E. Parker presented a paper by Dr. George Otis Smith, head of the Geological Survey, in which he took the issue with some of Dr. Raymond's statements and opinions.

* * *

Case Hardening of Special Steels.

A paper by Dr. Albert Sauveur and Mr. G. A. Reinhardt, of Harvard University, entitled "Note on the Case Hardening of Special Steels," was presented by Mr. Reinhardt. The authors point out that although many metallurgists know that some pearlitic special steels can be made troostitic, martensitic, and even austenitic, without quenching, and, therefore, without exposing them to the dangers of the quenching bath, the practical significance of such possibility does not seem to have received the attention it deserves.

With reference to the constitutional diagram of nickel iron carbon steels it is pointed out that theoretically starting with pearlitic steel, then by increasing the carbon content or the nickel content, or both, the metal should become martensitic

and eventualy austenitic. In this way there should be a possibility of imparting to the metal, without quenching it, the properties of hardened carbon steel. In other words, the steel is now self-hardening. Nickel cannot be introduced into solid steel, but by the well-known process of case hardening it should be possible to cause pearlitic nickel steel to absorb the necessary amount of carbon to become martensitic, or, even, if desired, austenitic.

It should, therefore, be possible to manufacture case-hardened objects of nickel steel and of some other special steels having pearlitic and consequently soft and tough cores and troosto-martensitic, martensitic, martenso-austenitic or austenitic cases, without recourse to the quenching bath. The authors give the results of some experiments showing the practicability of the manufacture of case hardened articles of this description. For instance, steel containing some 3.5 per cent of nickel can be made martensitic by case hardening followed by air cooling. Slow cooling in the furnace produces a sorbito-cementitic case.

Further, in case-hardening nickel-steel containing about 5 per cent of nickel, austenitic or martensitic cases can readily be produced through proper regulation of the length of the operation and by cooling in air the case-hardened articles. Slow cooling in the furnace produces sorbito-cementitic cases.

By reheating to 1000 deg. C. a steel with a sorbito-cementitic case (because of slow cooling in the furnace) and cooling in air, the case became martensitic. This suggests the advisability of cooling in the furnace after case-hardening, producing a corbito-cementitic case and then reheating to 800 deg. C. and cooling in air, thereby securing a finer martensitic case than by cooling in air from the case-hardening temperature.

Mr. C. R. Corning presented a few additional remarks on the proposed changes of the constitution and by-laws and the meeting then adjourned with a hearty vote of thanks to the local committee and all who made the meeting so successful and enjoyable. Many members then enjoyed the opportunity of inspecting the different buildings of the Case School of Applied Science.

* * *

Excursions and Social Functions.

On the evening of Tuesday the members and guests of the Institute were entertained at an informal smoker at the Statler Hotel. There were many ladies present. The motion picture series "From Mine to Molder" was shown by courtesy of Messrs. Rogers, Brown & Company, with an accompanying explanation of Mr. Henry B. B. Yergason, of the staff of that company. Prof. James F. Kemp then made a very entertaining address, showing some of his remarkable mountain climbing photographs.

On Wednesday evening a well attended banquet was held at the Hotel Statler, with Mr. D. T. Croxton as a brilliant toastmaster. Addresses were made by Captain Hunt, Mr. William J. Mather, Mr. Philip N. Moore, Mr. Edward W. Parker, Mr. Edward H. Benjamin, Mr. William Kelly, Mr. Samuel T. Wellmann, Prof. James F. Kemp and Mr. Charles Kirchhoff. Telegrams of greeting were sent to "Uncle" John Fritz and Dr. R. W. Raymond.

Mr. Kirchhoff in his after-dinner speech offered another amendment of the proposed constitution to catch up with the spirit of the times. He proposed that in future in similar functions of the Institute the wife, daughter, friend or present or future sweetheart should follow each mere man speaker, but that the conservatism of the Institute should be maintained by reserving the last word for mere man.

The afternoons of Wednesday and Thursday were devoted to very interesting excursions. On Wednesday afternoon the American Steel & Wire Company was visited. On Thursday afternoon the plant of the National Carbon Company and the ore docks of Mr. M. A. Hanna & Co.

At the works of the National Carbon Company the party was taken through the well-equipped library, the arc-lamp testing laboratory and the dry-cell testing room. The manufacture of dry cells was shown through its various stages as well as the mixing and grinding rooms for the arc-lamp electrodes, brushes and cells. The process of forcing arc-lamp carbons through dies and the molding of carbon brushes and dry-cell electrodes under hydraulic pressure were shown. The furnace room was visited in which the carbon products are baked. The party finally visited the brush-testing laboratory where tests are made of the specific resistance, strength, hardness, density, as well as friction tests at various speeds and contact-resistance tests at different brush pressures and current densities.

The whole visit was exceedingly enjoyable and the visitors were placed under great obligations to Mr. J. S. Crider, general manager, and Mr. H. A. Barren, general superintendent, of the National Carbon Company, as well as to the various members of the staff of the company who showed the visitors around. •

For the visiting ladies an automobile ride through Cleveland's boulevards was given on Tuesday afternoon, followed by a tea at the Country Club.

In the following we give a complete alphabetical list of all members and guests who registered at the meeting. When no city is stated, Cleveland is meant:

Robert Abbott, Mark A. Ammon; J. S. Applegate, Youngstown, Ohio; A. Arluck, A. O. Backert, A. C. Badger; H. Foster Bain, San Francisco, Cal.; H. A. Barren; W. H. Barrows, Jr., Duluth, Minn.; Edward H. Benjamin, San Francisco, Cal.; C. A. Bever; W. H. Blauvelt, Syracuse, N. Y.; R. P. Bowler, New York; Arthur I. Braid, New York City; H. T. Braman, Youngstown, Ohio; M. S. Brayer, Sharon, Pa.; J. H. Byrne; L. W. Callender, C. S. Carey; H. O. Chute, New York; Thos. H. Clagett, Bluefield, W. Va.; W. W. Coe, Roanoke, Va.; L. A. Collier; Geo. L. Collord, Sharon, Pa.; Edgar I. Cook, Pottstown, Pa.; C. R. Corning, New York; Jenning S. Cox, Jr., Santiago de Cuba; W. N. Crafts, Benedict Crowell, Mr. and Mrs. D. T. Croxton, S. W. Croxton, H. D. Dalton, A. E. Danforth; E. V. D'Envilliers, Philadelphia, Pa.; Mr. and Mrs. L. E. Dunham, Mr. and Mrs. F. A. Emmerton; W. E. C. Eustis, Boston, Mass.; Augustus H. Eustus, Boston, Mass.; A. I. Findley, New York City; E. L. Ford, D. D. Fowler, P. A. Fruehauf, Charles H. Fulton, H. F. Fulton; James Gayley, New York City; Stephen L. Goodale, Pittsburgh, Pa.; A. L. Gresham, New York; C. L. Griswold, Pittsburgh, Pa.; H. C. Hale; I. H. Hamilton, New York City; N. V. Hansell, New York City; H. T. Harrison; Elwood Haynes, Kokomo, Ind.; R. P. Heston, Toledo, Ohio; Henry D. Hibbard, Plainfield, N. J.; Henry H. Hindshaw, Alpena, Mich.; W. H. Hoyt; Mr. and Mrs. Geo. S. Humphrey, New York City; Robert W. Hunt, Chicago, Ill.; J. D. Ireland, Duluth, Minn.; L. E. Ives; F. G. Jewitt, Minneapolis, Minn.; Mr. and Mrs. J. E. Johnson, Jr., Ashland, Wis.; Nason Johnson, Alpena, Mich.; Mr. and Mrs. William Kelly, Vulcan, Mich.; J. F. Kemp, New York City; Paul H. King, Philadelphia, Pa.; Mr. and Mrs. Charles Kirchhoff; G. F. Knapp, Wm. Koehler; H. M. LaFollette, LaFollette, Tenn.; Frederick Laist, Anaconda, Mont.; E. F. Lake, Horace W. Lash; A. R. Ledoux, New York City; I. P. Lihme, J. B. Livingston; E. J. Longyear, Minneapolis, Minn.; D. A. Lyon, Pittsburgh, Pa.; A. G. McKee; W. W. Macon, Brooklyn, N. Y.; J. W. Malcolmson, Kansas City, Mo.; S. W. Marshall, Johnston, Pa.; H. A. Marting, Ironton, Ohio; Samuel Mather, W. G. Mather; Paul O. Menke, Sharon, Pa.; H. G. Merry, L. B. Miller; Philip N. Moore, St. Louis, Mo.; W. D. B. Motter, Jr., Trenton, Ont., Can.; Mr. and Mrs. C. B. Murray; Edward W. Parker, Washington, D. C.; H. P. Parrock, Buffalo, N. Y.; Wm. Fecanka; J. S. Pelton, New York City; Geo. W. Pfeiffer, Santiago de Cuba; C. B. Pierce; Mr. and Mrs. S. H. Pitkin, Akron, Ohio; Franklin Playter, Boston, Mass.; J. D. Price, New Straitsville, Ohio; John M. Price; Mr. and Mrs. Charles F. Rand, New York City; W. B. Ranney, Lakewood, Ohio; William Rattle, Jr., J. B. Read; G. A. Reinhardt, Cambridge, Mass.; J. C. Reitz, West Park, Ohio; F. B. Richard; C. Snelling Robinson, Youngstown, Ohio; F. F. Roeber, New York City; Willard N. Sawyer, C. A. Schaefer; F. Schniewind, Englewood, N. J.; Dr. W. Schumacher, Berlin, Germany; R. B. Sheridan; J. M. Sherrerd, Easton, Pa.; Albert W. Smith; E. Gybbon Spilsbury, New York City; S. C. Stillwagon, T. D. Stay, H. S. Stebbins; H. H. Stoek, Urbana, Ill.; Mr. and Mrs. Bradley Stoughton, New York City; Jos. Struthers, New York City; Mr. and Mrs. R. H. Sweetser, Columbus, Ohio; Mr. and Mrs. Knox Taylor, High Bridge, N. J.; R. B. Textor, Oscar Textor; Mr. and Mrs. J. Earlson Thropp, Jr., Indiana Harbor, Ind.; F. H. Treat; B. W. Vallat, Ironwood, Mich.; Frank R. Van Horn; Felix A. Vogel, New York; Karl E. Volk, West Park, Ohio; Fred F. Walther; C. M. Weld, Low Moor, Va.; S. T. Wellman, Edmund Wendel, M. T. Whelan, C. L. Wood; Walter Wood, Philadelphia, Pa.; Henry R. B. Yergason, Cincinnati, Ohio; G. A. Yoeum; Carl Zapffe, Brainerd, Minn.; Jeffries Zay.

River Water Used Eight Times.—Power can be developed upon many surface streams and applied to the recovery of the water of the streams after it has sunk into the earth in the lower lands of the valleys. An instance of this character according to the United States Geological Survey is to be found along Santa Ana River in southern California. After storing in a reservoir, it is used in succession in various power plants, for irrigation purposes, and for municipal water supply. In this particular case the same water is used in succession eight times for power and irrigation. (Water Supply Paper, 234, Geological Survey.)

Synopsis of Recent Chemical and Metallurgical Literature.

Gold and Silver.

Collection of Precious Metals as Speiss.—The way in which a supposed disadvantage was turned to good account is recorded by Mr. G. C. McMURTRY, in *Bulletin* No. 97, Institution of Mining and Metallurgy. The object of a certain smelting operation was to produce a low-grade copper matte high in gold. At odd times it was noticed that a small amount of speiss was formed in the smelting, and when this happened the value of the matte in gold decreased. The author believed that if this formation of matte could be controlled, it would form a good means of recovering the bulk of the precious metal. Experiments were therefore undertaken which resulted successfully.

The materials smelted consisted of raw concentrates, roasted concentrates and slimes from a previous method of treatment, copper ore and limestone flux. The roasted materials formed the largest portion of the smelting charge, but before smelting they were mixed with the raw concentrates and re-roasted.

The raw concentrates 13 to 33 per cent SiO_2, 29 per cent Fe, 26 to 30 per cent S, 14 to 20 per cent As, 1.5 to 3.5 per cent Sb, and 3 to 5 oz. Au per ton. The roasted concentrates and slimes had been roasted practically free from sulphur and arsenic, but contained about the same antimony as the raw concentrates. The copper was a pyrite containing about 8 per cent copper.

A bath of matte was formed, on which was charged the hot auriferous material from the roaster with some raw copper ore and limestone. Charging was continued until the matte assayed from 40 to 60 oz. per ton gold.

With a reverberatory furnace of good bottom the formation of speiss could be effected better in the furnace, but this was impossible on account of the poor condition of the furnace at the author's disposal. Consequently the matte was tapped into sand beds where it flowed over scrap wrought iron, with the resulting precipitation of antimonial speiss carrying a fair proportion of gold. The lower the percentage of copper in the matte, the better the gold recovery in the speiss. With mattes above 32 per cent copper the recovery was very small.

The speiss thus formed was separated from the matte, the latter being returned to the furnace to receive a new charge of roasted material, copper ore and limestone. The speiss was remelted in plumbago pots, and granulated by pouring into water.

The next operation was to give the speiss a sinter-roast in a conical pot holding about 40 lb. A false perforated bottom was placed in the pot, which was adapted to receive an air-blast. The granulated speiss was mixed with half its weight of silicious arsenical concentrate, a small handful of fine coal being added to each 21 lb. of mixture. A light fire was started on the false bottom of the pot, after which the mixture was fed gradually and a light blast turned on. Ultimately the pot was filled and roasted for about 1½ hours. The object of the roast was to render the iron and copper amenable to the treatment in the next step of the process.

This consisted in remelting the sintered speiss with copper ore, cyanide slag and sand. The copper was added in lieu of iron pyrite. The result of the operation gave an enriched speiss and a matte with some slag. The last was skimmed and the balance poured into molds and separated when cold.

The gold was finally recovered by cupelling the speiss with lead. The author realizes that the different steps of the process are not perfect, but they were adapted to conditions in an isolated position.

Magnetically-Removed Iron from Mill Pulp.—In a paper published by A. McA. JOHNSTON in the August, 1912 *Journal* of the Chem. Met. & Min. Soc. of S. Africa, the author gives the results of an investigation of the presence and effect of metallic iron in the pulp circulating in cyanide mills. The following summary of his results is given.

1.—Iron is obtained chiefly from the crushing plant, and is mostly present as small pieces, smaller than a pea, or as fine powder. It tends to accumulate in the tube-mill circuit.

2.—Iron in this state interferes with amalgamation and with regrinding in the tube-mill, while it consumes cyanide in the leaching vats.

3.—When removed from the pulp, this product can be easily oxidized by exposure to the atmosphere, wetting and turning over frequently.

4.—Failing any better means of disposal, this oxidized product will, if fed into the circuit, yield an average percentage of its gold to amalgamation and cyaniding.

Copper.

Flotation of Ore.—The application of the minerals separation flotation process on a copper ore in New South Wales is described in *Bulletin* No. 97, by J. W. ASHCROFT. The former treatment of the ore was by concentration on jigs and tables, and it was the tailings and middlings from this process that were treated by flotation.

The author describes at some length his experience in finally adopting the process to his ore and gives the following conditions for successful working.

1.—The particles must be clean and free from oxidation.

2.—The gangue must not be so clayey as to form a coating on the sulphide particles.

3.—The material treated requires to be ground as evenly as possible; the best size must be determined for each ore.

4.—The feed to the separating machine and the speed of the stirrers must be correctly proportioned and kept as even as possible.

5.—The thickness of the pulp fed to the machine must be regulated and kept even.

6.—The minimum amount of mineral present in the feed must be determined.

7.—The water used has a marked effect on the process and necessitates modification according to its hardness and chemical constituents, but a bad water is not necessarily detrimental.

Assaying.

Preparation of Samples.—Mr. W. B. BLYTH calls attention to the necessity of proper preparation of mine samples, if the resulting assay is to be of value. His paper appears in the July, 1912. *Journal* of the Chamber of Mines of Western Australia. The main point to be observed is the size to which samples must be crushed before the successive quartering operations are performed. He gives detailed results of many assays on a variety of ores, the mine samples of which varied in quantity.

The point is absolutely demonstrated that the samples considered must be crushed finer than ¼ in. before a representative portion for assay can be quartered from them. The results from working on the ¼-in. product are so erratic that they are useless. The author advises that the size to which various ores must be crushed before the quartering process begins must be determined for each ore. But his general results on a wide variety of ores indicates that the required size lies somewhere between ¼ in. and 10 mesh. He advocates the use of a jaw crusher delivering a ¼-in. product; a second crusher reducing to 10-mesh; and a disk pulverizer as best adapted to the proper preparation of samples.

Stamp Mills.

Performance of Stamps.—In the *Journal* of the Chamber of Mines of Western Australia for August, 1912, Mr. W. R. DEGENBART gives details of the operation of a unit of two Holman pneumatic stamps working on a mixture of hard and soft ore. The screens are 12-mesh; horsepower consumed ranges from 30 to 34 hp per unit; drops per minute, 123 to 135; capacity of the unit, 130 tons per day; consumption of shoes,

0.248 lb. per ton ore crushed; consumption of dies, 0.199 lb. per ton; weight of shoes, 224 lb., weight of dies, 177 lb.; water used, 1200 gal. per ton of ore crushed. By comparison with gravity stamps, the two Holman stamps excelled the performance of 15 gravity stamps.

Recent Metallurgical Patents.

Copper.

Hydrometallurgical Extraction of Copper.—The extraction of copper from its unroasted ores is the basis of a patent granted to José Baxeres de Alzugaray, of New York City, who has assigned his process to the Midland Ores & Patents Company, of New York City. The principle of the process is the use of a solution of iron and copper chlorides together with an alkali chloride and hydrochloric acid. As an example of the application of the process the inventor takes an ore containing 2.5 per cent copper, 25 oz. silver and 0.25 oz. gold per ton and treats it with the following solution: Ferric and ferrous chlorides, 10 parts; cuprous and cupric chlorides, 2 parts; sodium chloride, 20 parts; hydrochloric acid, 20° B., 4 parts; water, 64 parts, and sodium manganate, 0.1 part.

Under the action of this solution the copper and silver will be converted into chlorides and held in solution. The oxidizing action of the sodium manganate will liberate chlorine which will attack the gold, and will also regenerate ferric and cupric chlorides after their action on the ore. By the addition of small amounts of oxidizing agent the solution is kept at its full strength, and after precipitation of its contained copper, silver and gold by suitable means it can be used again as a solvent for further metals. (1,041,407, Oct. 15, 1912.)

Process of Roasting Copper Ores for Extraction by Water.—In a patent granted to Mr. Utley Wedge, of Ardmore, Pa., the inventor discloses his proposed means of roasting ores containing copper oxide, carbonate or silicate in the presence of sulphurous gases, whereby the copper is converted into copper sulphate, which may be washed out by water. From the solution thus obtained the copper may be precipitated in any desired manner. The preferred form of furnace for the operation is a muffle furnace of the superposed-hearth type designed by the inventor.

In operation, the ore is fed into the furnace on the top hearth, and sulphurous gas is admitted at the bottom hearth or any other that may be preferable. The gas should contain not less than 3 per cent by volume of SO_2, and preferably 14 to 16 per cent. Some oxygen will have to be admitted with the gas to permit of conversion of the copper ores into copper sulphate. The temperature should be maintained at from 800 deg. to 1100 deg. F., and care should be taken to prevent so high a temperature that the formed copper sulphate will be decomposed. An effective manner of carrying out the process is to use it in connection with an ordinary roasting furnace, the hot sulphurous gases from which can be conducted directly into the furnace in which the copper ore is being treated. (1,043,490, Nov. 5, 1912.)

Alloy.—Jesse Jones, of Wilmerding, Pa., assignor to Westinghouse Electric and Manufacturing Company, claims the following alloy to have an "exceptionally high degree of resistance" to any and all strains to which it may be subjected: 51 to 64 parts of copper; 35 to 45 of zinc; 1/6 to 15 of a hardener, specified below; 1/3 to 3 of tin, and 1/6 to 8 of an aluminium, when the composition is required for casting. The hardener consists of tin, ferromanganese and magnet or high-speed tool steel or some other special steel in the proportion of 30:7½:62½ by weight. (998,777, July 25, 1911.)

Zinc.

Improved Retort Furnace.—In order more effectively to heat zinc retort furnaces of the type in which the exit flue for the products of combustion is placed at one end of the

furnace chamber, Mr. Charles A. H. de Saulles, of Gas, Kans., has patented an improved design, which is illustrated in section in Fig. 1. In furnaces of this type the retorts d are supported on front and rear walls, the latter being also walls of a down-take b connecting with a flue and stack C. Gas and air for combustion are introduced into the muffle chambers through a series of ports.

It will be understood that the draft of the stack C on the air and gas ports will vary progressively from one end of the chamber to the other, causing non-uniformity in the heating of
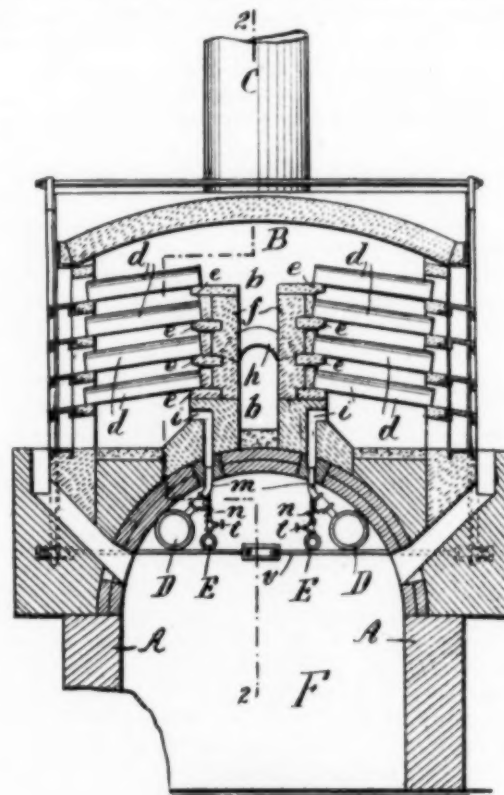

FIG. 1.—ZINC RETORT FURNACE.

the retorts in different parts of the furnace, and thus affecting the regularity and efficiency of the smelting operation. The present invention is designed to overcome this difficulty so as to permit the retorts in all parts of the furnace to be heated uniformly, and thus enable the smelting charge in different parts of the furnace to be worked off in the same period of time. To this end the inventor supplies his furnace with air and gas under pressure, delivered through the main pipes placed under the heating chamber. The gas main is shown at E and the air main at D. Branch pipes from each main conduct the air and gas to ports placed horizontally, in pairs, as shown at i. Each of the branch pipes is controlled by a valve, as at n and t. By appropriately adjusting these independent valves according to the pressure of the air and gas in the mains and according to the draft of the stack, it is possible to realize with substantial accuracy equalized conditions of temperature throughout the length of the combustion chamber. (1,041,977, Oct. 22, 1912.)

Treatment of Refractory Zinc-Lead Ores.—A patent has been issued to Mr. Andrew G. French, of Nelson, B. C., on a process for treating zinc-lead ores which are refractory to known methods of separation and recovery by methods of concentration and smelting. The essential feature of the proposed method is the conversion of all the zinc into a sulphate by heating with niter cake, or sodium bisulphate. This will render the zinc soluble, in which condition it can be separated from the lead and recovered in any manner, as by electrolysis. The ore must first be roasted, after which it is mixed

with the ground niter cake in a quantity varying from 5 to 15 per cent of the original weight of the ore. This mixture is then brought to a dull red heat in a reverberatory furnace. The reaction occurs quickly, and the product remains in a loose pulverulent condition. It is then leached with water and washed with a solution of sodium bisulphate, whereby the zinc sulphate is dissolved and can be separated from the lead sulphate. (1,041,060, Oct. 15, 1912.)

Recovery of Zinc from Galvanized Articles.—The recovery of zinc from galvanized-iron scrap may be accomplished by treatment with a solution containing a mixture of alkali bisulphate and a chloride of a metal whose hydroxide has an alkaline reaction. According to a patent granted to EDUARD BROEMME, of St. Petersburg, Russia, and RUDOLF STEINAU, of Nuremberg, Germany, 100 kilos of galvanized iron scrap of 9 per cent zinc is boiled with a solution of 20 kilos sodium
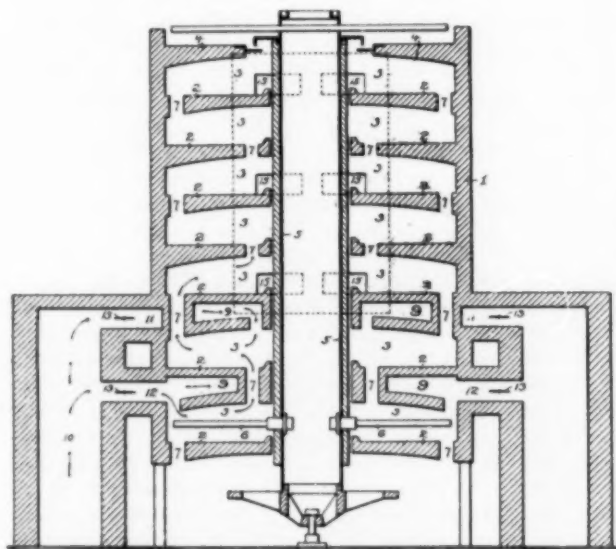

FIG. 2.—ROASTING FURNACE WITH HEATING CHAMBERS.

bisulphate and 20 kilos of common salt, until all zinc has gone into solution. This will result in a very pure solution containing zinc chloride, sodium sulphate and sodium chloride, containing only traces of iron and manganese, which can be used for the production of lithophone. The sodium bisulphate and salt react to form sodium sulphate and to liberate hydrochloric acid which attacks the zinc, forming zinc chloride. The zinc-lye thus obtained can then be treated with barium sulphide, whereby the following reaction will occur:

$$ZnCl_2 + Na_2SO_4 + BaS = ZnS + BaSO_4 + 2NaCl.$$

The resulting precipitate can be used directly for the manufacture of lithophone-white. (1,042,315, Oct. 22, 1912.)

Metallurgical Furnaces.

Roasting Furnace with Heat-Equalizing Chambers.—In Fig. 2 is shown a design of multiple-hearth roasting furnace patented by MR. UTLEY WEDGE, of Ardmore, Pa., in which the products of combustion are applied directly to material under treatment. The feature of the furnace is the heating chambers 9, the purpose of which is to maintain an equal heat, and to regulate the temperature in the different roasting chambers of the furnace. The superposed hearths are shown at 2, and the hearth-chambers at 3. The furnace has a central rotating shaft 5 provided with projecting arms and rabbles 6, shown only in the lowermost hearth-chamber. In order to make the heat more equable throughout the furnace, the heating chambers 9 are connected with the fire-boxes 10 by flues 11 and 12. A portion of the products of combustion pass from the fire-boxes through the flues into the heating-chambers as well as into the hearth chambers, as shown by the arrows. For the further regulation of the heat in the treatment-chambers, gas out-

lets are provided as shown at 15, which are adapted to be opened or closed as conditions may require. If, therefore, the temperature in the upper hearths is too high, a portion of the gases may be drawn off through the gas-port in a lower chamber. (1,040,071, Oct. 1, 1912.)

Channel Furnace.—In our issue for October, 1912, page 659, we published a description of a new process for the manufacture of alumina, hydrochloric acid, caustic alkali and a
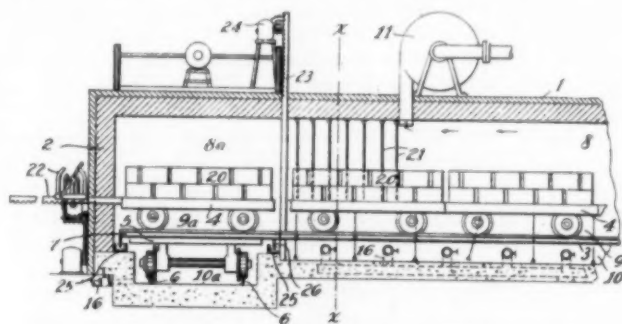

FIG. 3.—PORTION OF CHANNEL FURNACE AND VESTIBULE

white hydraulic cement from salt, clay and lime. A feature of the process was the use of a tunnel or channel furnace, which has been patented by MR. ALFRED H. COWLES, of Sewaren, N. J., author of the article mentioned. The furnace, which is a modification of the Gronwall channel furnace, consists of a long tunnel or channel, provided with tracks over which are run cars carrying briquets of the mixture to be treated. Means are provided for preventing the deleterious gases which may be formed in the upper part of the furnace from penetrating below the body of the cars and attacking any corrodible parts of the cars and furnace. Fig. 3 shows a longitudinal section through a part of the furnace 1, together with the vestibule 2, into which the briquet-bearing cars 4 are run on a truck 5, before being pushed into the furnace by the pusher 22. The body of the furnace is divided into upper and lower parts 8 and 9 by the car bodies. The briquets of material are shown at 20. A suction fan 11 is placed at the top of the furnace near the entrance, for exhausting the hydrochloric
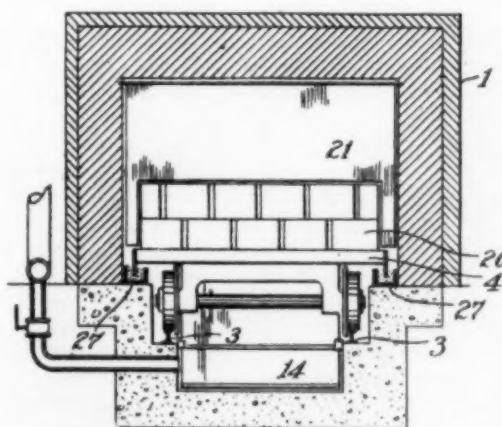

FIG. 4.—SECTION OF CHANNEL FURNACE.

acid gas produced by the reaction in the briquets. A blower also is provided to supply gas or air under pressure to the portion of the furnace below the car body. The branch air supply pipes are shown at 16. Baffles of sheet metal attached to the bottom of the cars divide the lower part of the furnace into a number of sections, while in the upper part of the furnace are hung a series of curtain baffles, fitting quite closely to the surface of the load on the cars. These baffles form a seal against the exit of the gases while the cars are traveling into the furnace. An adjustable door leading into the furnace

from the vestibule is shown at 23. Metal sheets fastened onto the sides of the car dip into a sand seal as shown at 25 in Fig. 7. The ends of the cars are made to fit as closely as possible, asbestos packing being attached to the end of each car.

Following is the application of the furnace in the manufacture of hydrochloric acid and alkali-silico-aluminate. The charge mixture composed of clay, salt and carbon, in the proportions, say, of 35 per cent to 65 per cent clay, 30 per cent to 50 per cent alkali chloride and 3 per cent to 10 per cent carbon, is briquetted and loaded on the cars and introduced into the vestibule. The vestibule is then closed and the door 23 of the furnace opened. By means of the pusher 22, the car is then gradually pushed into the furnace, forcing forward the cars already introduced, the mixture on which is undergoing conversion. While the car is being introduced into the furnace, the baffles above and below the car prevent the exit of any gases into the vestibule. Within the furnace the charge is subjected to the combustion gases which enter through the side walls of the furnace, and also to the action of steam and air which is blown into the furnace against the direction of travel of the cars. The chemical reaction of the charge evolves hydrochloric acid gas which is drawn off to a condensing system by the fan 11. This gas is kept in the upper part of the furnace by the devices already mentioned, where it is at a temperature of more than 220 deg. F., and therefore does not attack the iron of the cars. To prevent its ingress to the lower, or cooler part of the furnace below the cars, the blower is used to blow air into the portion of the furnace below the cars, and maintain a balance of pressure between the upper and lower parts of the furnace, or a slight upward pressure from the lower to the upper part. (1,040,895, Oct. 8, 1912.)

Iron and Steel.

Electric Steel Melting.—The literature on electric furnaces and the production of steel therein as contained in the U. S. Patents is abundant, very diversified, sometimes genial and sometimes full of commonplaces. There are two patents, however, recently granted to two men, both prominent in the field of electric furnace metallurgy, which are well worth studying. Both aim at the production of a more highly purified steel, each one in a different way, and both will give a decided impulse to practical operation no matter whether they will be carried out literally or with modifications.

Treatment of Molten Steel.—Prof. **Joseph W. Richards**, of Lehigh University, South Bethlehem, Pa., has already given a brief of his views while discussing a paper read before the recent International Congress of Applied Chemistry, as abstracted on page 603 of this volume of this journal. According to his ideas steel which has been finished by any of the well-known processes should be transferred to the electric furnace and held there in liquid state for a suitable length of time without adding any reagents such as are usually added to oxidize, deoxidize or otherwise refine it. The electric furnace will in this case merely be a "holding furnace," and among the objects attained by this "holding operation" may be catalogued the escape of gases, the floating up of impurities, the fixation of evolved impurities by union with the lining of the furnace, the completion of the intimate alloying of the ingredients of the steel, an increase in liquidity of the metal, and the exact regulation of the casting temperature. Twenty-nine different methods or combinations of methods of ordinary basic or acid steel making, and also including electric melting, are enumerated as processes preceding the final holding operation. Professor Richards prefers the induction furnace for use in this last step in the series of operations; he also prefers an acid-lined electric furnace and he apparently must be congratulated upon having solved the hitherto open problem of continually operating an induction furnace with an acid lining. (1,037,536, September 3, 1912.)

Manufacture of Steel is the title of a patent of the well known inventor, **Paul Girod**, of Ugines, France. His pre-

vious European patents dealing with the same subject have already been mentioned on p. 136 of Vol. 17, of the Transactions of the American Electrochemical Society (1910). Those who are both scientifically and practically interested in steel making know that during the cooling down of steel from the liquid to the solid condition there is a range of temperature at which the oxygen of the residuary oxides dissolved in steel acts on the carbon by forming CO. The evolution of this gas seems to evolve other gases simultaneously. Mr. Girod makes use of this phenomenon and claims to cool the steel transferred in molten state to the electric furnace down to 1250 deg. or 1300 deg. This is best effected by having cold scrap of the same or a purer composition in the furnace when the steel is poured in. In this process it is supposed that the steel has been dephosphorized in a preparatory furnace such as Bessemer converter or open-hearth, whereby the oxidation is carried less far than is hitherto common practice. A sufficient amount of oxidizable elements, such as about 0.10 to 0.15 per cent carbon, 0.1 to 0.2 per cent silicon and 0.2 to 0.3 per cent manganese, is left in the metal or is artificially added in cases where the circumstances required a more thorough oxidation of the bath. In being cooled down rapidly in the electric furnace this steel ejects gases up to the moment when the material becomes pasty. It is then reheated under a reducing slag, until the latter is entirely fluid, the remainder of the gases escapes and the alloying additions can now be made to tap and pour the steel. "Triple silicates of manganese, iron and silicon" are said to be instrumental in forming a readily fusible slag in the first phase of operations. (1,043,090, November 5, 1912.)

Open-Hearth Furnace.—Present open-hearth practice requires to shut down the furnace for a cleaning of the slag pockets. Mr. **Horace E. Smythe**, of Pittsburgh, Pa. (assignor of the S. R. Smythe Company), avoids this inconvenience by certain new devices. In order to remove dust, fluxes, metallic substances and the like from the waste gases issuing from the furnace chamber the gases are led into small chambers with inclined sole arranged at the bottom of the downgoing gas flues. From here they pass into the slag pockets, moving downward through these and entering the checker chamber from below. The checker chamber itself is divided into two unequal parts; the one entered by the waste gases first is the smaller one. After rising upward the gases reach the arch of the checker chamber extending uninterruptedly over both parts and pass downward in the usual way through the main part of the checker work. This arrangement allows the bulk of the impurities carried away from the furnace to accumulate in the first named auxiliary chamber with inclined bottom. A tapping device facilitates air removal from here without interrupting the operation of furnace. The slag pocket itself only needs to be cleaned out in longer intervals and any dust which should be carried beyond the slag pocket can still settle in the flues below the first part of the checker work. The latter is thus prevented from being clogged and an even heating of the air and gases guaranteed. (1,042,047, October 22, 1912.)

Soaking Pit.—Mr. **Horace E. Smythe** furthermore provides a soaking-pit top with means which will prevent its destruction by the intense heat within. The cover of the pit is divided into individual sections. A plunger or other moving device travels along the end of the cover sections and carries near each end a pivoted latch which may be swung so as to connect with lugs in any of the cover sections. The plunger can then be operated to open any desired part of the pit. Adjacent to the wheels which carry the covers is an inclined track which causes the cover to rise as it moves from over the opening, and means are provided permitting the axles of the wheels to move downwardly after the cover is seated on the furnace. (1,044,093, November 12, 1912.)

Non-corrosive Iron-Nickel Alloy.—Two patents issued to Mr. Robert B. Carnahan, Jr., of Middletown, O., refer to the very pure iron which has been placed on the market, as especially resistive to corrosion, by the American Rolling Mill

Company, of Middletown, O. According to his present patent he purifies molten iron to such an extent that its content of carbon, phosphorus, sulphur, silicon and manganese combined does not exceed 0.14 per cent, with oxygen reduced to not more than 0.05 per cent. He finds that the corrosion-resisting qualities of this iron may be still further increased by alloying with it a metal such as nickel, so that the finished alloy will contain, say, 99.30 per cent. iron, 0.50 per cent nickel, not more than 0.14 per cent carbon, phosphorus, sulphur, silicon and manganese combined, and not more than 0.05 per cent oxygen. The alloy may be made in an open-hearth furnace by first refining the iron to the condition indicated, adding the alloying metal and then pouring the molten mass into a ladle containing a deoxidizing agent, such as aluminium at the rate of 2½ lb. per ton. The proportion of alloying metal added will be determined by the use to which it is to be put, consistent with the cost of the nickel. If high cost is justified by the results, the inventor states that an alloy can be produced thus which will be practically proof against corrosion. (1,035,947, Aug. 20, 1912.)

Combination Process for Steel Manufacture.—With the intention of utilizing the best features of the open-hearth furnace, Bessemer converter and electric furnace, Mr. FRED B.
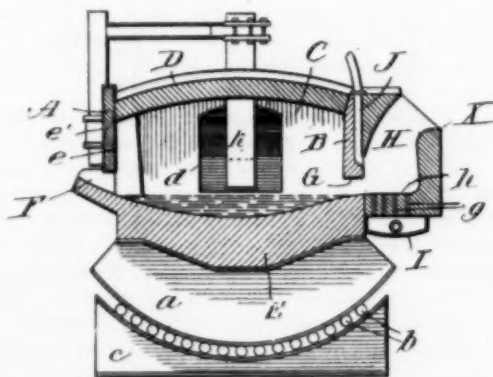

FIG. 5.—COMBINATION OPEN-HEARTH CONVERTER
AND ELECTRIC FURNACE

LAMB, of Bettendorf, Ia., has patented a combination furnace. While the basic open-hearth furnace is adapted to the removal of carbon, silicon, manganese, phosphorus, and possibly sulphur, the operation is expensive and requires considerable time; and the baser the raw materials, the more difficult and more expensive does the operation become. On the other hand, the Bessemer converter has proved itself an excellent means of decarbonizing and desiliconizing; the basic open-hearth furnace excels in dephosphorizing; and the electric furnace has proved best in the removal of sulphur and as a deoxidizer. The inventor, therefore, proposes to combine all these features in a single tilting open-hearth furnace with converter and electric attachments.

The furnace is shown in three positions in Figs. 5, 6 and 7. It consists of the usual tilting-furnace structure, the curvature of the concave tracks being struck from the center of the gas port d, in the end walls of the furnace. The gas ports are provided with vertically movable gates which can be lowered and raised from the outside. The charging port is at e, which is normally kept closed by a door e'. The Bessemer converter consists of a chamber H, air-box I and air-passages g. An air-flue J also is provided at this part of the furnace, the function of which will appear later. Extending down through the roof of the furnace are electrodes k, which are adjustable vertically.

In operation, the furnace is charged with, say, 15 tons of pig iron. As the carbon content of the pig iron would be high, oxidation would commence at once, and the entire charge would be melted in about two hours. When about 5 tons of

metal had accumulated in the bath, and after the blast had been turned on in the converter, the furnace would be tilted toward that end as shown in Fig. 6. This part of the metal would then be decarbonized and desiliconized, and its temperature raised from 1800 to 3000 deg. F. The highly acid slag which would be formed could then be poured off, the operation being facilitated by directing a blast of air through the flue J. The furnace would then be tilted back to a horizontal position as shown in Fig. 5. Due to the increased tempera-
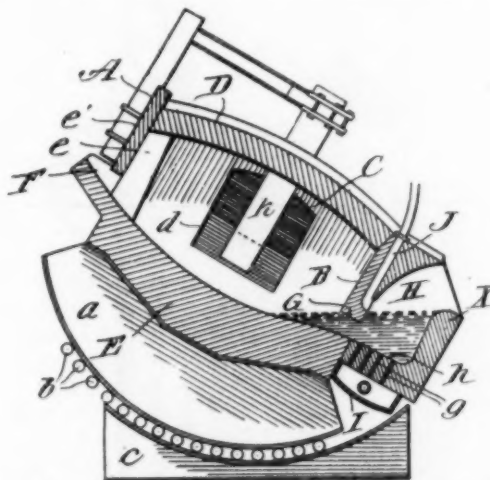

FIG. 6.—COMBINATION STEEL FURNACE AS CONVERTER.

ture of the 5 tons of metal which had been bessemerized, and its impregnation with oxidizing gases, the reduction of the unmelted portion of the bath would be hastened and its carbon oxidized. During this operation, dephosphorization has gone on without interruption, and at the end of about two hours the entire charge will be melted and its content of carbon, silicon and phosphorus reduced to the proper limits. Further the temperature of the bath will be at a high point. There remains then to be eliminated the occluded gases and the sulphur. The electric process is, therefore, now brought into play for the purpose of removing the gases and sulphur. The result of the combined processes is claimed by the inventor to be steel of the
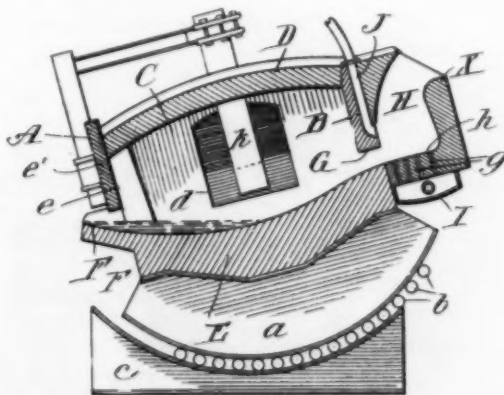

FIG. 7.—COMBINATION STEEL FURNACE IN
POURING POSITION

highest grade obtainable, which may then be poured by tilting the furnace in the position shown in Fig 7. (1,036,498-499-500, Aug. 20, 1912.)

Heating Furnace.—Heating furnaces of the "over-fired" type, that is furnaces in which the combustion takes place above the heating chamber and the fire gases are discharged downwardly from the combustion chamber into the heating chamber are regulated quickly and accurately with greater difficulty than direct-fired furnaces. In a furnace, for instance,

having a double arch which forms the combustion chamber, and flues rising in the side walls of the furnace from the bottom up into the main flue, the rising of the heat can be checked by closing the burner or by opening the door. The first means would not be effective at once in the heating chamber but for
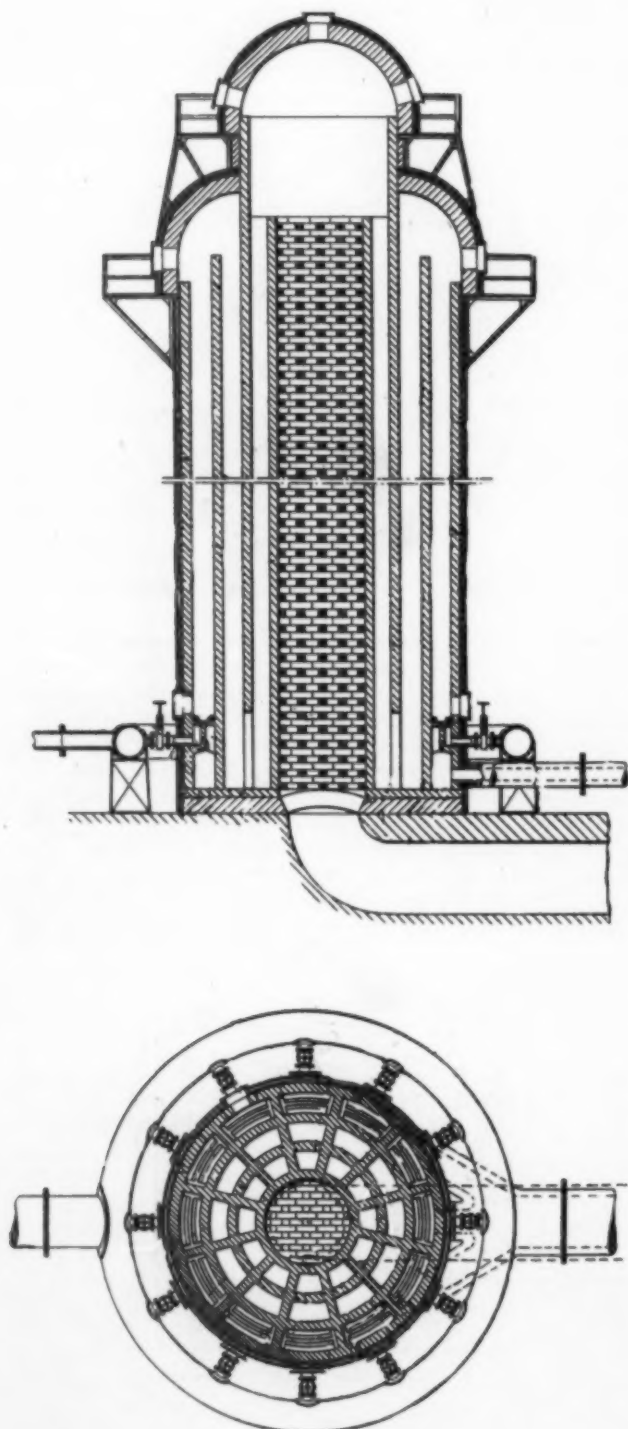

FIG. 8.—AIR-BLAST HEATER.

quite some time later on, the second would cool the furnace non-uniformly. Mr. **Wirt S. Quigley,** of Rockaway Park, N. Y., therefore controls the heat of such furnaces by providing a regulating relief passage in the top of the combustion chamber. This can be closed or partially or wholly opened. When opened it permits the escape of the heat from the combustion chamber without passing into or through the heating

chamber. A drawing shows this invention as a hole in the roof covered by a damper plate. (1,039,801, October 1, 1912.)

Regenerative Reversing Furnace.—Mr. **Luther L. Knox,** of Avalon, Pa., supplies the parts of an ordinary open-hearth furnace most exposed to wear and tear by action of the beat with suitable water cooling devices. In his previous U. S. patent 973,943, of October 25, 1910, he has already shown the plurality of water-cooled plates of which his cooling device for the roof wall of the furnace consists. The same principle of hollow plates is now used for cooling, by means of separate top, side and bottom members, the gas ports of such furnaces, the gas and air uptakes and the side walls and door openings. A more detailed description would require quoting the entire text of the patent. (1,041,814, October 22, 1912.)

Regenerative Furnace for Tube Welding.—With the present type of welding furnace it is difficult to keep pace with the rapid production because the doors are partially open during most of the time and admit an excess of cold air; the heating is also non-uniform in the wide furnaces in which the flame has to pass too large a distance. Mr. **Peter Patterson,** of Pittsburgh, Pa., solves this problem by dividing each furnace into two smaller ones which can be handled by the same charging machine and by providing ample regenerators under these furnaces and gas flues under the hearth. The dividing wall between the two furnaces receives so much heat that it is cooled by a system of water pipes. One furnace can always be kept closed and serve as heating furnace while the other one is being discharged. (1,038,640, September 17, 1912.)

Air-Blast Heater.—Mr. **Edmund Hohmann,** of Stettin, Germany, has designed a new form of the air heaters in use in connection with blast furnaces. The majority of the air blast heaters now in use in Germany have the combustion chamber on one side of the checker work. This does not utilize the heat of the gases as well as the new nested design which is entirely symmetrical, having three annular flues outside enclosing a central cylinder of checker work which connects to the stack. The annular chambers are radially subdivided into sections. The hot furnace gases entering from the outside toward the center of the device and the heated air passing in the opposite direction cause a slower movement of the gases in the hotter parts of the heater where the sections are larger, and an increase of speed of the cooler gases which pass through the still colder or cooling-off sections. While the circular arrangement is shown in the accompanying Fig. 8, the inventor finally claims any sort of section. (1,038,887, September 17, 1912.)

Converter.—Mr. **Alexander F. S. Blackwood,** of Detroit, Mich., has designed a Bessemer converter which can be more readily repaired than is ordinarily the case with converters. The characteristic feature of the new type is that it consists of two parts which can be easily joined together and separated, the separating plane passing just through the locality at which the maximum wear of the lining of the converter occurs. According to illustrations this line runs right above the trunnion ring. After loosening holding shackles the upper portion of the converter can be lifted up by a crane, thus enabling the bricklayer to repair the lining after but a few hours of cooling, whereas from 15 to 18 hours are commonly required before a man can enter into it to repair the lining. This arrangement reduces the number of converters required to produce a certain output. (1,042,876, October 29, 1912.)

Furnace Top.—A new variety of charging device for blast furnaces by **Frank C. Roberts,** of Wynnewood, Pa. See our September issue, p. 554, U. S. P., 1,033,036. (1,033,034 and 1,033,035, July 16, 1912.)

Crucible Furnace.—Mr. **Wilhelm Buess,** of Hanover, Germany, has designed a new means of heating a filtable crucible furnace using liquid or gaseous fuel. Opening 39 of the accompanying drawing shows the entrance of the flame, the diametrically opposite opening 40 with lid 41 is an emergency discharge of gases and of liquid material from broken crucibles.

Chamber 17 below the bottom of the furnace is kept cool by passing the pressed air of combustion through said chamber and preheating the air. When the air is hot enough it can also be switched over to the burner direct without passing through chamber 17. The other features of the furnace are self-understood from Fig. 9. (1,044,012, November 12, 1912.)

Reduction of Ores.—By a process, somewhat similar to the Talbot process of reducing iron ore in a tilting open-hearth furnace, the well-known electrical inventor Dr. **Elihu Thomson** proposes to produce iron or steel direct from ore. By using, for instance, a basic-lined converter, he melts down a bath of iron and introduces a blast of ordinary or of enriched air to
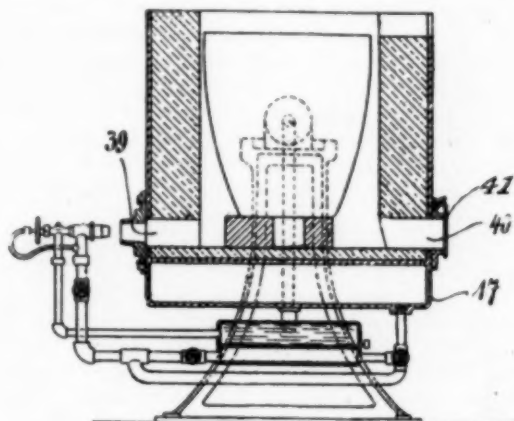

FIG. 9.—CRUCIBLE FURNACE.

thoroughly oxidize the iron to the magnetic oxide state. By using air enriched in oxygen a higher temperature is reached. The nitrogen is carried off for other uses by means of appropriate conveyors; its heat can be utilized to preheat the raw materials which are used during the next stage of the process. A mixture of ore and carbon with suitable slagging agents are now introduced into the liquid bath, the carbon being in such amount as to take care of the combined oxygen in the ore and in the liquid bath. It may also be charged in excess when it is desired to increase the heat by the oxidation of the carbon. This stage of the process produces metallic iron and carbon monoxide in a nearly pure state, which is suitable for utilization in gas engines, for heating, etc. Part of the charge is then poured off and finished by the proper addition of ingredients, as soft iron for steel. The remainder of the charge is oxidized as before, and the circle of operations begins anew. (1,031,490. July 2, 1912.)

Treating Ores.—Mr. **Edward Kerr**, of Pittsburgh, Pa., describes a method of treating ore, more particularly iron ore, alternately with superheated steam and air in a muffle furnace and then separating mechanically (by a magnetic separator) the metallic portion of the charge from other solid constituents. The muffle is externally heated by passing products of combustion through flues below the bottom and above the arch. Between the bottom flues tubes are arranged with nozzles in the bottom of the furnace through which steam and air are directed into the charge. The forcing of steam and afterwards of air into the pieces of ore disintegrates the same, and the metallic parts after being separated from other solid ingredients can be mixed with carbon and molten in the usual way. They can also be mixed with a suitable binder and first pressed into blocks. (1,032,007, July 9, 1912.)

Method of Producing Practically Pure Iron.—The wooden poles are familiar implements in copper refineries. **Archibald Smith**, of Tarentum, Pa., assignor to the Allegheny Steel Company, makes use of sticks of spruce or other coniferous woods to refine steel in an open-hearth furnace. Carbon, manganese, phosphorus, sulphur, silicon and oxygen are removed from the bath to the greatest possible extent by the

application of heat, fluxes and reagents, according to the well known basic open-hearth process. During this treatment sticks of wood are forced below the surface of the metal bath and after they are consumed are replaced by others until the violent agitation and ebullition of the bath which ensues has ceased. By this process the bath is deoxidized without increasing the carbon content. This highly purified product will solidify without blowholes or spongy top, is less susceptible to corrosion than any other known iron, highly malleable and ductile, etc. (1,008,377, Nov. 14, 1911.)

Iron-Silicon Ingot (Rustproof Iron).—Ordinary Bessemer and open-hearth steels rust more than wrought or puddled iron. The manganese, used as a deoxidizer, is apt to segregate and increase the rate of corrosion. **Eugene A. Byrnes**, of Washington, District of Columbia, assignor to Pittsburgh Pure Metal Products Company, therefore proposes to manufacture, preferably in the basic open-hearth, a product containing up to 99.7 per cent iron, not over 0.15 per cent total carbon, sulphur, phosphorus, manganese, oxygen and nitrogen, and 0.15 per cent or more of silicon. The temperature of the furnace is kept high. The combined oxygen is then removed by silicon (used as 50 per cent alloy) and titanium (in the form of a 30 per cent alloy). Silicon is added in sufficient excess to leave from 0.10 to 0.15 per cent in the finished product, titanium preferably in the minimum amount necessary to eliminate oxygen and nitrogen. In some cases it may be desirable in order to obtain a high temperature and facilitate the final reaction, to tap the metal into an electric furnace, thereby largely removing the slag in transit. (1,004,987, Oct. 3, 1911.)

A New Type of Rotary Gas Producer.

The announcement of several large gas producer contracts recently awarded the Chapman Engineering Company calls attention to a radically new type of gas producer which is the invention of Mr. W. B. Chapman, of 11 Broadway, New York City. It is manufactured by the C. & G. Cooper Company, of Mount Vernon, Ohio, who are also largely interested in the Chapman Engineering Company.

The Chapman rotary gas producer, as shown in the accompanying illustration, performs three distinct operations, one for each of the three steps necessary to the process of making producer gas, viz.:

1. Mechanical feeding and spreading the fuel.
2. Mechanical agitation of the entire firebed.
3. Mechanical removal of the ash.

These, in brief, are the three fundamental ideas around which this producer is built, and in its design the solution has been found for the complete mechanical control of all three of these necessary steps.

Automatic Feed.

The first unique feature of this producer is that its "mechanical" feed has no mechanical parts.

Another feature is that fine and coarse coal are handled simultaneously without separating the coarse from the fine. Heretofore in mechanical feeds a spout or bell has usually been resorted to with the result that the fine fuel was liable to drizzle off from the end of the spout into the center of the producer, while the coarse fuel bounded from the spout with sufficient force to carry it to the walls, the result being a separation of the fine from the coarse coal in the fire bed, very much to the detriment of the operation of the producer. With the Chapman feed this separation is made impossible.

The fuel chamber is stationary and has no bottom. It has a capacity of 1000 lb. of coal—enough to last for half an hour. The lower edge is water-cooled. As the revolving fire bed comes under the chamber, a fresh supply of fuel is spread over the surface, thus constantly keeping the level of the fire bed up to the bottom of the fuel chamber.

The lower edge of the fuel chamber is beveled so as to pro-

duce a down-stroking effect upon the fire bed as it passes under it, thus "rubbing in" the fresh fuel.

An interesting feature of the Chapman feed is that it is the only one that will feed the coal in unevenly as conditions require. Heretofore the effort has been to drop the coal evenly over the fire bed. Logically, however, the coal should be fed into the producer unevenly, not evenly; for obviously when holes and crevices start to form in the surface of the fire bed
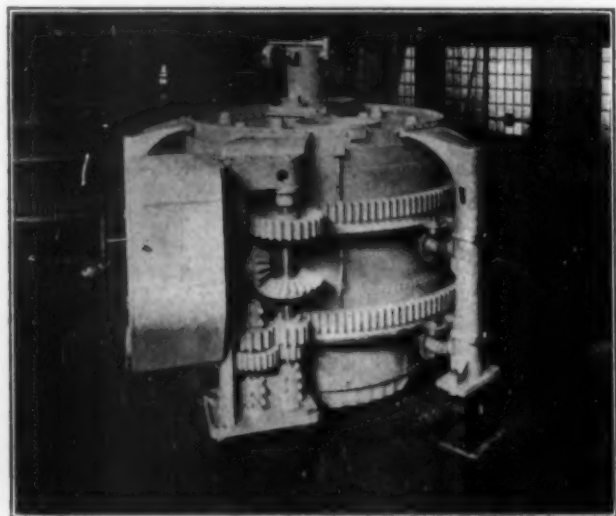

FIG. 1.—CHAPMAN ROTARY GAS PRODUCER.

more coal is required at these points than elsewhere.

The fuel chamber also prevents a rush of soot into the flues each time fresh fuel is charged into the producer. The tarry gas first given off from the coal in the fuel chamber must pass down through the hotter fire at the bottom of the chamber before it can escape to the flue. This reduces the amount of tarry smoke in the gas.

The Illinois Steel Company made a continuous test of this feed for the month of August, 1911, at their works at South Chicago. As compared with the operation of the hand-poked producers at this plant, this test showed the following results:

1. An increase of 19.1 per cent in the strength of the gas.

2. A decrease of 42 per cent in the quantity of steam required per ton of coal gasified.

3. The elimination of 83 per cent of the soot deposited in the flues.

After nine months' trial of this machine they ordered four more.

Agitating Without an Agitator.

The second distinctive feature of this machine is the means used for agitating the fire bed. Some years ago the Chapman company discovered that the best method of agitating a gas producer was to revolve one-half of the fire bed over the other, thus setting up a twisting and shearing action throughout the entire fire bed. The producer is therefore divided horizontally through the hot zone into an upper and lower section, and the two sections are made to revolve in the same direction, but at different speeds.

Each section of the wall carries with it that portion of the fuel bed which it surrounds. Thus the maximum amount of agitation is produced through the hot zone where it is most required. The unique feature of this second step in the process is that adequate agitation is obtained without recourse to an agitating member.

Agitating arms or beams are limited in their action to a comparatively small portion of the fire bed at any given time, thus leaving the balance of the fire bed to become disorganized. It is claimed that agitating members in the fire bed leave in their wake a gap or recess detrimental to the operation of the

producer, and they burn off in about six months, in spite of being water-cooled, if they project into the hottest portion of the fire.

Prevention of Clinkers.

The chief difficulty in manufacturing producer gas is the prevention of clinkers. Clinkers are caused by excessively hot spots in the fire bed. These hot spots are caused by uneven spreading of the coal, or uneven agitation of the fire bed, or uneven distribution of the air blast, or uneven removal of the ashes. Uneven conditions in a producer make blow-holes, "chimneys" or "pipes" in the fire bed. If left alone these holes become rapidly larger, and the temperature about them increases until the fusing point of the ash is reached. Clinkers then start to form about each of these hot spots, and when once formed, it is a matter of considerable difficulty to remove them. If the excessively hot spots are avoided and the uneven conditions prevented, there will be no clinkers.

In the Chapman producer the twisting of the upper half of the fire bed over the lower shears off the holes as fast as they tend to form. This action together with the fuel spreader and the continuous ash removal effectually prevents the formation of clinkers.

This freedom from blow-holes in the Chapman producer is evidenced in the unusually low temperature of the gas (about 1200 deg. Fahr.) and also in the lack of soot. So small is the amount of soot made that the Chapman Engineering Company have recently been able to enter into a contract guaranteeing that an installation of three of these producers will operate continuously for two months without requiring a shut-down for flue cleaning.

Ash Removal.

The last step in the process of making producer gas, that of removing the ash, is accomplished in this producer in an equally novel manner. The ashes are first ground between the sides of the stationary corrugated air box or "ash crusher" and the revolving corrugated wall of the lower section. In mechanical producers the crushing of the ashes is a very necessary preliminary to their removal, as otherwise an occasional large chunk would block the operation. After the ashes have been crushed they are forced up to the top of the ash pan by three
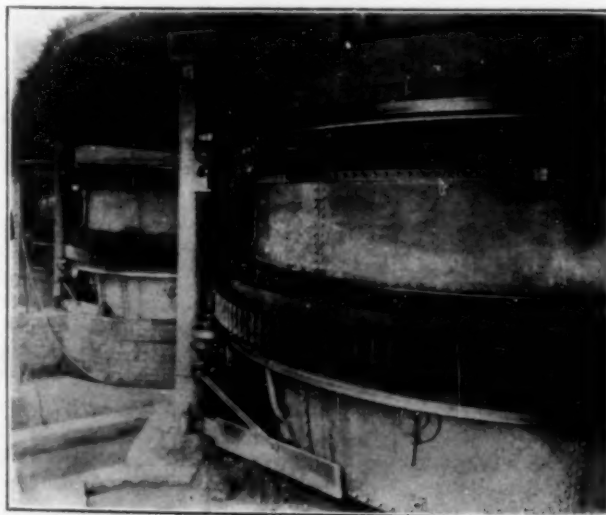

FIG. 2.—INSTALLATION OF CHAPMAN ROTARY GAS PRODUCERS IN STEEL PLANTS.

adjustable ash plows. These three ash plows are kept continually in operation, and are easily adjusted when occasion requires, which is not often.

As fast as the ashes are lifted to the surface of the water in the ash pan they are automatically scooped up and carried to the required point for automatic discharge. The fact that the ashes in being removed are removed upward instead of down-

ward makes a saving of several feet in the height required for the gas house and foundation.

There is little or no advantage in removing the ashes mechanically if they cannot be removed continuously. Heretofore all mechanical ash removing devices have been intermittent, operating for possibly an hour once or twice in twenty-four hours. This invariably resulted in a badly disorganized fuel bed, requiring several hours to rectify. The ash-removing device in the Chapman producer is the first to fill this important requirement of being continuous.

Capacity.

As a result of the joint action of the automatic fuel spreader, the twisting of the fire bed, and the continuous removal of the ash this producer may be made to gasify a ton of coal an hour
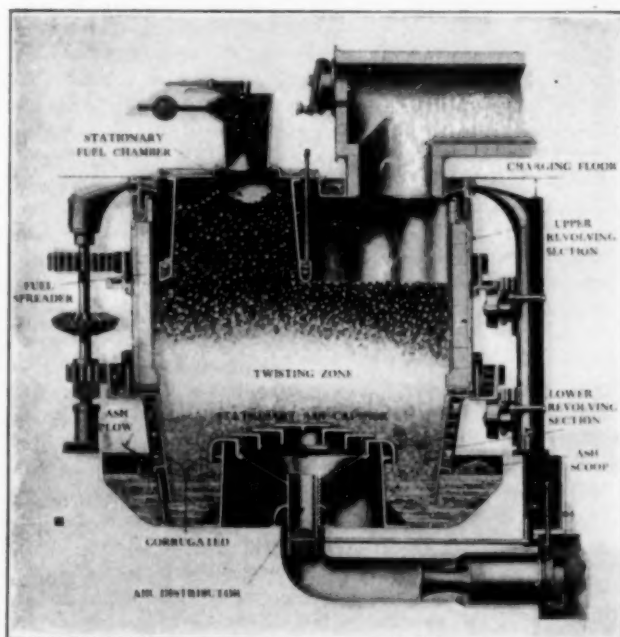

FIG. 3.—SECTIONAL VIEW OF CHAPMAN ROTARY GAS PRODUCER.

—at least twice the capacity of the ordinary hand-operated producer, and at the same time the quality of the gas is greatly improved and more uniform.

Record at Cleveland and Youngstown.

In ordinary practice with the old-style hand-operated producers the gas usually varies about 20 per cent in strength during each day, while the weekly variation is usually over 40 per cent. The Chapman Engineering Company believe they have established a new record for uniformity of gas production. The greatest amount of variation in a two-weeks' test at the Consolidated Works of the American Steel & Wire Company, in Cleveland, was only about 2½ per cent. At this plant three producers have been in operation since November, 1911, one of them (the first order) has been in operation two months longer. The average results of a two-weeks' test, conducted by the American Steel & Wire Company, in April, 1912, at this plant showed the following gas:

ANALYSIS.

Combustible	B.t.u.	CO₂	ILL	O	CO	H	CH	H
42.22	150.8	6.54	0.51	0.31	21.91	17.1	2.70	50.90

The greatest variation from the average of 150.8 B.t.u. was but 2.54 per cent, the poorest gas having 147.34 B.t.u. and the best 154.6 B.t.u.

A similar producer has been in operation at the plant of the Youngstown Sheet & Tube Company, Youngstown, Ohio, for

nearly two years with even better results than the above. The CO₂ has averaged between 4 and 7 per cent and the CO between 20 and 25 per cent, while the B.t.u.'s have kept close to 160.

The Youngstown Sheet & Tube Company has recently awarded contracts to the Chapman Engineering Company for five additional producers.

As a result of their investigation of the Chapman producer at the Youngstown plant, the Brier Hill Steel Company, of Youngstown, placed an order a few months ago for twenty-two of these machines for their new open-hearth furnaces and soaking pits.

The details of this machine have been worked out with unusual care; no expense seems to have been spared and the result resembles Corliss engine practice rather than gas producer construction. For example, the following is rather unique construction for a gas producer:

The supporting rollers run on high-carbon steel pins and are provided with brass bushings. These rollers are cast in a chill and ground. Separate rollers are used to take the side-thrust; all rollers are mounted in pairs set in equalizing yokes; all bearings are provided with large oil wells filled with waste after the manner of railroad cars. The faster gears run in oil. Steel castings are used extensively both in the gears and throughout the balance of the construction.

Six years of continuous effort were put upon this producer before it was ready to be placed upon the market.

An Improvement in Screw Conveyor Design for Abrasive Materials.

In the handling of cement products, ashes, or other abrasive materials, with screw conveyor, delays and expense are caused by the necessity for renewals, because at each journal bearing where the flights are discontinued there is an obstruction offered to the flow of the material along the trough by the journal bearing support or hanger, and the interruption of the conveying spiral at that point. This tends to accumulate material and imposes extra work on the end-flight in pushing it past the bearing into the path of the next section.

Experience shows that this extra work wears away the end of the delivery flight and its outer edges, until the accumulation extends back farther and farther from the bearing, thus losing efficiency for the conveyor and finally forcing the renewal of the whole section.

The end-flights may be practically worn away, while the rest of the conveyor may show but little wear. Thus Fig. 1

FIG. 1.—WEAR OF ORDINARY END-FLIGHTS AFTER 3 WEEK'S SERVICE.

shows the results of wear after three weeks' service in handling cement clinker with ⅝-in. standard reinforced steel flights. Heretofore when a coupling gudgeon wore down in this way and needed renewal, it required considerable work to remove and replace the old gudgeon, and the shut-downs necessary for renewals of conveyor sections and coupling gudgeons caused serious interruptions.

This difficulty has been overcome successfully by a clever invention of the late D. D. Drummond, vice-president and

general manager of the Chicago Portland Cement Company. Mr. Drummond's invention makes renewals easy, and furnishes end-flights made of material which is high in wear-resisting properties. The end-flight, generally made of manganese or other hard and tough steel, has a center or hub whose recess is large enough at one side to receive the end of the conveyor shaft or pipe, and small enough at the other side to fit the end of the coupling gudgeon. The adjacent gudgeon ends of the two end-flights are provided with removable caps which permit the coupling gudgeon or the end-flights to be taken out or replaced without disturbing the rest of the conveyor. As

FIG. 2.—DRUMMOND END-FLIGHTS WITH COUPLING GUDGEON ASSEMBLED.

the end-flights are secured to the gudgeons and to the conveyor shafts or pipes by bolts, it is a simple matter to make renewals when necessary.

Fig. 2 shows the Drummond end-flights with coupling gudgeon assembled complete. The removable cap is omitted from the right end to show detail of arrangement.

The improvement obtained with this device is remarkable. In the same service which wore out the ⅝ steel flights of Fig. 1 in three weeks, the Drummond end-flight stood up well and its condition is shown in Fig. 3 after six months of this severe service. Careful measurement showed only ¼-in. wear

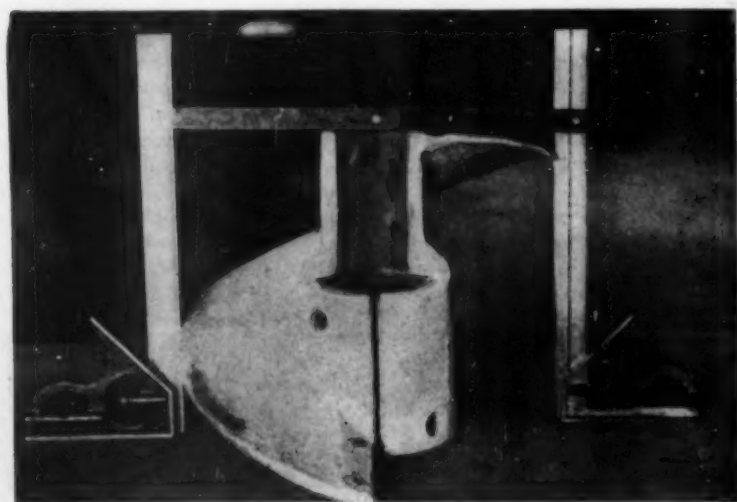FIG. 3.—DRUMMOND END-FLIGHT AFTER 6 MONTHS OF THE SAME SERVICE AS FIG. I.

on the outer edges (or ½-in. total diameter). The delivery end of the flight was worn thinner, but was still intact, and the opposite end had full thickness.

After the device has proven its reliability and success in actual severe practice it is now being placed on the market by the Link-Belt Company of Chicago, Philadelphia and Indianapolis.

The London *Electrical Review* celebrated its fortieth birthday in its issue of November 15. The first issue appeared on November 15, 1872, the title being *Telegraphic Journal*. The words *"and Electrical Review"* were added in 1873.

Personal.

Mr. **Cyril J. Atkinson**, the inventor of the Atkinson gas producer, has severed his connection with the Dornfeld-Kunert Company of Watertown, Wis. Mr. Atkinson's services and the use of all his patents have been secured by Fairbanks, Morse & Company, of Chicago, and a number of Mr. Atkinson's inventions will be incorporated at once in the Fairbanks-Morse gas producers.

Dr. **Gustave Drobegg** has resigned his position with Charles Pfizer & Company, with whom he had been chief chemist for twenty-five years, and is now associated with Mr. Alois von Isakovics, proprietor of the Synfleur Scientific Laboratories, as chief chemist of his manufacturing laboratories.

Dr. **Paul Héroult** sailed for France on November 23rd with the steamship "La France" for a stay of several weeks.

Dr. **Hugo Lieber**, general manager of the Blau Gas Company, has returned on the "Kronprinzessin Cecilie" from his European trip.

Mr. **Robert Woolston Hunt** will be the guest of honor at the reception to be tendered to him by the American Institute of Mining Engineers, the American Society of Mechanical Engineers, and the American Institute of Electrical Engineers, on the evening of December 5th, at the Engineering Societies' Building. The John Fritz Medal for 1912 will be awarded to him on this occasion by the Board of Award, consisting of representatives of the four national organizations of the civil, mining, mechanical and electrical engineers. The medal is awarded to Mr. Hunt for "his contributions to the early developments of the Bessemer process."

Mr. **L. E. Saunders**, who has been in charge of technical and research work for the Norton Company, manufacturers of abrasives and refractories, at its alundum plant at Niagara Falls, N. Y., and its crystolon (silicon carbide) plant at Chippewa, Ontario, has been made general superintendent of the two works in addition to his former duties. No change in the personnel at the two plants will be made at present except the transference of Mr. S. F. Hull, who has been associated with Mr. Saunders as operating superintendent, to the main works of the Norton Company at Worcester, Mass., where he will be plant engineer.

Mr. **B. Viola** has resigned as managing and chief engineer of Messrs. Chas. Pfizer & Company, with whom he was associated for sixteen years, and will open a consulting engineer's office for the equipment and installation of chemical and allied industrial works and power plants.

Mr. **Hugh M. Wilson**, first vice-president of the McGraw Publishing Company, has been elected president of the American Trade Press Association of New York.

Coal Miners.—The total number of men employed in the coal mines of the United States in 1911, according to the United States Geological Survey, was 722,335, of whom 172,585 were employed in the anthracite mines of Pennsylvania and 549,750 in the bituminous and lignite mines. The anthracite miners averaged more working time than the bituminous miners, working 246 days, against 211 days for the bituminous miners. The average production for each man employed was 524 tons in the anthracite mines—an exceptionally large tonnage—and 738 tons in the bituminous mines. The average daily production for each man employed was 2.13 short tons in the anthracite and 3.50 tons in the bituminous mines. In most of the bituminous mines of the United States the 8-hour working day prevails. In 1911, out of a total of 549,750 employees in the bituminous coal mines, 330,045 worked 8 hours a day.

Digest of Electrochemical U. S. Patents.

Prior to 1903.
Arranged according to subject matter and in chronological order.
Compiled by Byrnes, Townsend & Brickenstein, Patent Lawyers, National Union Building, Washington, D. C.
ORE TREATMENT (*Continued*).

619,349, Feb. 14, 1899, Hugo Riecken, of London, England.

Relates to the electrolytic extraction of precious metals from ores or slimes by the solution of the precious metal from the ore and its deposition upon mercury in an easily-recoverable condition.

I employ a vat having a suitably shaped converging bottom and vertical or inclined sides lined with copper which may be silver plated, connected as cathodes. At the lowest point of the lining there may be arranged a gutter for the reception of mercury and near the upper edge of the lining is a pocket or trough extending wholly or partially around it and having openings or a slit over the metallic surface. The mercury is withdrawn from the bottom of the vessel through a tap and delivered into the pocket or trough near the top, whence it escapes through the slit or holes and descends in streams over the lining back into the gutter, a circulation of the mercury and a continuously-changing cathode surface being thus maintained. The anode is composed of rods or plates of carbon, metal, etc., fixed to a shaft, which is suitably rotated or oscillated to agitate the ore.

The slimy ores may or may not be first mixed to a pulp and introduced into the vat, which contains a suitable electrolyte, e. g., a weak solution of cyanide of potassium to which may be added a salt such as sodium chloride, which under electrolysis yields oxygen or an equivalent oxidizing agent to accelerate the solution of the gold, etc. The pulp is kept agitated by the anode stirrers and the anion which is generated at the anode gradually dissolves the precious metal, which, together with the potassium, is deposited upon the cathode and both amalgamated. If the gold in the ore is in a finely-divided state and soluble in the electrolyte without the aid of electrolysis its solution will be greatly accelerated by the use of the stirrers and the current will then deposit the gold. When the operation is completed the vat is opened and the finer slimes run out to settle. Any gold amalgam which may be found among the coarser particles may be separated on the concentrating table, the recovered amalgam being treated in the ordinary manner.

623,822, April 25, 1899, Louis Pelatan, of Paris, France, assignor to the General Gold Extracting Company, Limited, of London, England.

Relates to apparatus for use in the treatment of ores, sludges, pulps, solutions, or the like, containing gold or silver or both so as to obtain the precious metal in a more complete and satisfactory manner and with economy of the agents employed in the treatment. It contains a reference to his application for the process, which became patent 627,422.

Within a vat of any suitable material, such as wood, cement, etc., a revolving anode is suspended by a shaft, the anode having arms, the lower surfaces of which may be provided with anode-plates such as carbon, iron or steel, and which are parallel to a layer of mercury, constituting the cathode, on the copper, iron or cement bottom of the vat. The shaft is in metallic connection with the anode and completes the circuit through a brush contact; it is so mounted in its bearings that it can be readily raised and lowered to facilitate the recovery of the amalgam.

In order to sweep the sludge from the cathode and prevent it accumulating or settling thereon, the rotating anode-arms are provided with pins of wood, etc., projecting downward close to the mercury cathode, but not so close as to disturb the latter; and to prevent centrifugal action, the inner side of the vat is provided with inward projections or baffles so as to break up the moving mass of sludge and prevent it acquiring a continuous revolving movement in the space above the anode.

I have found that for the same vat the number of revolutions of the anode which is necessary to effect a given agitation in the sludge is inversely proportional to the square roots of the numbers of the arms in the anode. The maximum speed which can be used for stirring the sludge in such large vats without disturbing the mercury of the cathode varies both with the construction of the vat and the nature of the ore, but it is considered dangerous to run the anode at a greater speed than about 10 ft. per second at the extremity of the arms.

In use the pulverized ore, water and cyanide solution are introduced into the vat, the anode rotated at the desired speed and current passed between the anode and the sludge. Every particle of ore is subjected to the action of the cyanide solution and the electric current, the gold or silver is first dissolved by the solution and then amalgamated by the mercury cathode.

626,972, June 13, 1899, Thomas Craney, of Bay City, Michigan.

Relates to apparatus for the recovery by electrolysis of precious metals in cyanide of potassium solution obtained by the cyanide treatment of ores. Within a tank is placed axially a hollow core provided with openings at the bottom communicating with the outer space in the tank; or a conduit may enter the tank from the outside, through which the solution is supplied.

The electrode forming the cathode consists of a thin metal foil, such as lead, enclosed in a fold of a suitable fabric, such as cotton cloth, leaving a margin of the lead foil projecting; the anode consists of thin sheet iron or, preferably, wire screen, similarly folded in cotton cloth, leaving a margin projecting; the two inclosed electrodes are now placed one above the other with the margin of one projecting in one direction and that of the other in the opposite direction, coiled tightly about the hollow core and making a tight fit within the tank, leaving a space below the electrodes for the distribution of electrolyte. The anode is suitably secured to a plate at the bottom of the tank connected to a circuit; the cathode marginal edge extends above and is also connected to the circuit. A number of tanks may be placed in cascade, the solution entering the top tank through the axial hollow core, passing up between the electrodes and overflowing into the axial hollow core of the tank lower down, etc. After the electrolysis the cathode may be removed by taking out the electrode roll, uncoiling and separating the lead foil from the cotton cloth folds, a new electrode roll being inserted in the tank. The gold is recovered by cupeling the lead foil or otherwise.

627,442, June 20, 1899, Louis Pelatan, of Paris, France, assignor to the General Gold Extracting Company, Limited, of London, England.

Relates to processes for treating ores containing gold or silver or both and refers to an application which became patent No. 623,822, in which is described and claimed the apparatus used with this process.

With ordinary ores equal weights of ore and water are used, and as the specific gravity of ores increases less water is used. The conductivity of the water is increased by adding salt or a similar substance. With sludge or pulp giving an acid reaction to the water an alkali such as lime or caustic soda is added to neutralize it before the operation begins. Also should the solution become acid during the operation an additional quantity of alkali is added to maintain a neutral or slightly alkaline condition.

The solvent agent, potassium cyanide, is then added in quantities from 0.05 to 0.2 per cent of the weight of water used; if other cyanides are used quantities containing a similar amount of cyanogen radicle as the potassium cyanide are employed. With some ores an oxidizing agent, such as peroxid of sodium, permanganate of potash, etc., are used to hasten

the action of the cyanogen. The addition of peroxid of sodium also serves to neutralize acid ores. With neutral or basic ores an oxidizing agent such as picric acid is used in the proportion of less than 0.05 per cent of the solution. The precious metal is extracted partly by electrolytic action and partly by the solvent action of the cyanide solution.

In the presence of silver if this element or its compound is not readily soluble in the cyanide the sludge and solution is heated to between 80 deg. and 100 deg. C., sodium chlorid or other suitable chlorid being added. A stronger current than ordinarily used with gold ores is passed through the sludge for from two to four hours, resulting in chloridizing the silver or its compounds. The temperature is now lowered to less than 40 deg. C., and a gentle current passed; potassium cyanid in quantity to dissolve the silver chlorid and the gold present is now added; an oxidizing agent such as picric acid may also be added. The silver and gold are precipitated electrolytically and amalgamated by the mercury cathode. An electric current of $1\frac{1}{2}$ amp per square foot of mean electrode surface is advisable, but not less than 2 amp-hours per ounce of silver dissolved in the sludge should be used.

BOOK REVIEWS.

A Brief Laboratory Guide for Qualitative Analysis. By **Arthur E. Hill**, Ph.D., Associate Professor of Analytical Chemistry, New York University. 12 mo., 80 pages. Price, $1. Easton, Pa.: Chemical Publishing Company.

This is written as a guide to the briefest possible course in qualitative analysis, intended chiefly for civil engineering students. Confidence in the scheme is justified by the fact that the author has used it six years in the laboratory and achieved satisfactory results with students who devoted eighty-five hours to the laboratory work and fifteen hours to lectures. But Dr. Hill attempts too much for the limited time at his disposal; the explanations given (in fine print) are too technical (and often too hypothetical) for his class of students and would be much better understood and more useful if made simpler and from a more general standpoint. Nevertheless, under skillful supervision, we do not doubt that students using this little book learn a good deal of qualitative analysis.

* * *

Die Elektrochemische Industrie Frankreichs. By **M. R. Pitaval**; translated into German by Dr. **Max Huth**. $16\frac{1}{2}$ x 25 cm. 140 pages. 35 illustrations. Price 8 marks. Halle: Wilhelm Knapp.

An interesting review of the electrochemical industries of France, rather padded in spots, to keep up appearances. The most important parts are 15 pages on the chlorine industry, 22 pages on calcium carbide, 18 pages on fixation of atmospheric nitrogen, 15 pages on the production of aluminium, and 33 pages on electric furnace steel and ferro-alloys.

While the work is in many places carelessly written, and must in consequence be read critically, yet there are items of information contained in it, here and there, which have not been published before, and which may prove valuable to persons particularly interested.

* * *

Das Hydrosulfit. By Dr. **Karl Jellinek**. Part I: Physical Chemistry. Part II: Inorganic, organic and technical chemistry. 16 x 25 cm., 188 and 230 pages; price 6 marks each part. Stuttgart: Ferdinand Enke.

These two books form vol. XVII and XVIII of Dr. Herz's "Sammlung chemischer und chemisch-technischer Vorträge." The first part has for its object "to illuminate from the physico-chemical standpoint the properties and reactions of this most useful class of salts, which are so easily decomposed, so energetic as reagents, and therefore useful to such a high degree in the dyeing and textile printing industries." The amount of information gathered together on this one topic is

remarkable, and must prove invaluable to all technologists using this class of salts. Electrochemists will be particularly interested in a 25-page chapter on its electrolytic production from bi-sulphites.

In the second part the author regrets that practical details of its manufacture have not been published, and that he is forced to give extracts from patents as the only available information.

The various properties and uses in inorganic chemistry are given systematically, but probably the most valuable part of the whole work is the 46 pages devoted to the reactions of these salts on organic compounds, the basis of their large use in the organic chemical industries.

* * *

The Hydrometallurgy of Copper. By **Wm. E. Greenawalt**, C. E., B. S. Part I: Roasting. Part II: Hydrometallurgical Process. 15 x 23 cm. (6 x 9 in.), 504 pages, 112 illustrations; price $5.00 net. New York: McGraw-Hill Book Company.

The author very properly gives a large space, 155 pages, to roasting processes, because of their importance in preparing sulphide ores for leaching. The roasting to copper sulphate, the most important desideratum for subsequent leaching, is, however, much too meagerly handled, scarcely more being said on this head than the sentence: "For a sulphatizing roast, the temperature should not exceed 650 deg. C." The circumstances call for a detailed discussion of the influence of temperature, quickness of heating, length of roasting, effect of other sulphides, effect of addition agents (e. g. $FeSO_4$), nature of gangue, etc., on the per cent of copper convertible into sulphate by roasting.

The real leaching processes are handled at length and in general quite satisfactorily. One hundred pages are given to the chemical-alkali processes, and eighty pages to electrolytic processes. The treatment is fair and satisfactory. Other chapters deal with the extraction of gold and silver from copper ores, treatment of zinciferous ores, treatment of copper-nickel matte, working up of bluestone, power data and economic considerations.

We are fortunate in having such a desirable addition to our abundant English copper literature; it is a useful, timely, and valuable compilation.

* * *

A Text-Book of Rand Metallurgical Practice. Vol. II. Design and Construction of Plants: Transport of Materials. By **C. O. Schmitt**. $6\frac{1}{4}$ x 9 in. (16 x $22\frac{1}{2}$ cm.). 438 pages, 455 illustrations. Price, $6.50 net. Philadelphia: J. B. Lippincott Company. London: Charles Griffin & Company, Ltd.

Part I, written by eight different experts, describes the geology, mining, milling, chemistry and operation of the cyanide process on the Rand. This volume is written entirely by Mr. Schmitt. It describes sorting and breaking plant, crushing plant, amalgamating plant, clean-up apparatus, cyanide plant, purer supply and transportation of materials. Electrical precipitation plant is omitted, from which we infer that it has gone entirely out of use on the Rand. The book is intensely practical, and may be fairly called a model of description of metallurgical construction.

* * *

The Technical Analysis of Brass and the Non-Ferrous Alloys. By **W. B. Price** and **R. K. Meade**. 5 by $7\frac{1}{2}$ in. ($12\frac{1}{2}$ x 19 cm.). 267 pages, 17 illustrations. Price $2.00 net. New York: John Wiley & Sons.

The book describes the analytical determination of 16 metals occurring in common alloys, and then the analysis of 16 of the commonest alloys. In brass, the separation and determination of Sn, Pb, Al, Fe, Mn and P are given, in addition to Cu and Zn. Bronzes, nickel alloys, babbitt metals, solders and light aluminium alloys are handled separately; also, at the end, the analysis of commercial zinc and copper.